DECEMBER 1989 BYTE 5 NEW LAPTOPS • SOUND AND IMAGE PROCESSING • CASE TOOLS Volume 14, Number 13

SETTING THE STANDARDS
15
YEARS

In Depth: Sound and Image Processing

BYTE

DECEMBER 1989

A McGRAW-HILL PUBLICATION

PRODUCT FOCUS:
HANDS-ON TESTS OF SEVEN CASE TOOLS

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MIT's Media Lab

Understanding Protected Mode

Mac System 6.0.1 vs. OS/2 1.1

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Bricklin and Frankston on the Beginnings

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REVIEWS

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February 14, 1989

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††640 KB versions of the above systems are available for an additional $80.
100 MB hard drive configurations also available.

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- Page mode interleaved memory architecture.
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- Socket for 25 MHz Intel 80387 or 25 MHz WEITEK 3167 math coprocessor.
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All systems are photographed with optional extras.

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In benchmark after benchmark, the 25 MHz Dell System 325 ran circles around

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a field of 386-based systems. A field that included the Compaq® 386/25.

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As you might expect, the output is just as intense. You can choose between VGA Monochrome with

Circle 104 on Reader Service Card

powerCache 4 ...The most advanced What else would you expect

PC MAGAZINE, *January 1989,*
"In a field of powerhouse machines there can only be one winner, and ALR's FlexCache is it."

INFO WORLD, *July 1989,*
"ALR Systems Unleash 486 Power. The PowerCache 4 shines in the CPU-specific portion of the InfoWorld Automated Benchmark Test, gaining a score of 16.3."

PC WEEK, *July 1989,*
"Based on a series of benchmarks run last week on Advanced Logic Research, Inc.'s prototype 486 desktop system, ALR will enter the 486 market with a bang."

At ALR, we will never rest on our laurels. We strive to be the best, as proven by our past achievements. Now with the introduction of the new ALR PowerCache 4™, we've designed a system that is far beyond comparison. Again, we have taken PC-microprocessing power a step further by designing a unique proprietary PowerCache 4 cache controller using ALR's custom ASIC chips which deliver the fastest processing speed ever.

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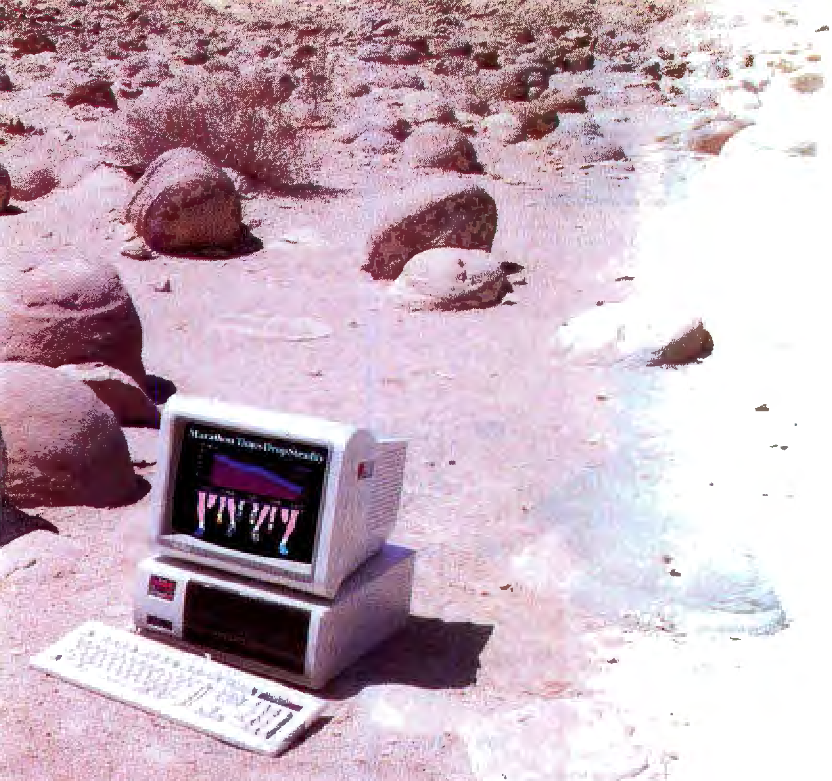
CPU	25 MHz i486	25 MHz i486	25 MHz i486
Bus	MCA	MCA	MCA
External Cache	128 KB cache Read and Write-Back	128 KB cache Read and Write-Back	None
Video Opt. on board	640x480 1024x768	640x480 1024x768	640x480 None
I/O Slots	6 expansion slots	6 expansion slots	3 expansion slots
Storage Expansion	4-3 1/2"	1-full height 2-1/2"-height 2-3 1/2" drives	3-3 1/2" drives
Disk Capacity	130 MB-260 MB	150 MB-650 MB	110 MB
Price	$9,990	Starting at $11,490	$12,990



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BYTE

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COVER STORY

Laptops Forever

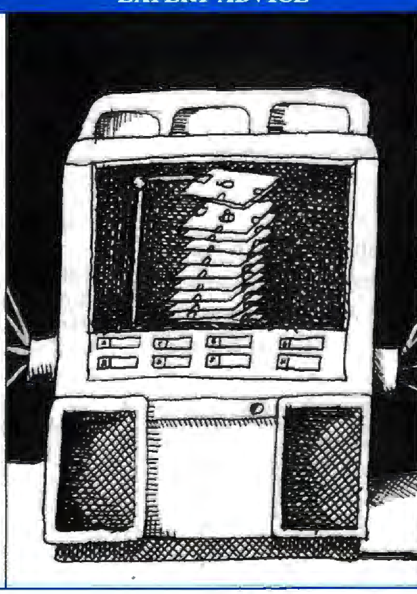
by Frank Hayes, Michael E. Nadeau, and Stan Miastkowski

page 93

New laptops from Compaq, GRiD, Toshiba, and Zenith point to the future of small computing.

PRODUCTS IN PERSPECTIVE

EXPERT ADVICE



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IN DEPTH

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Ten Years of Rows and Columns/324

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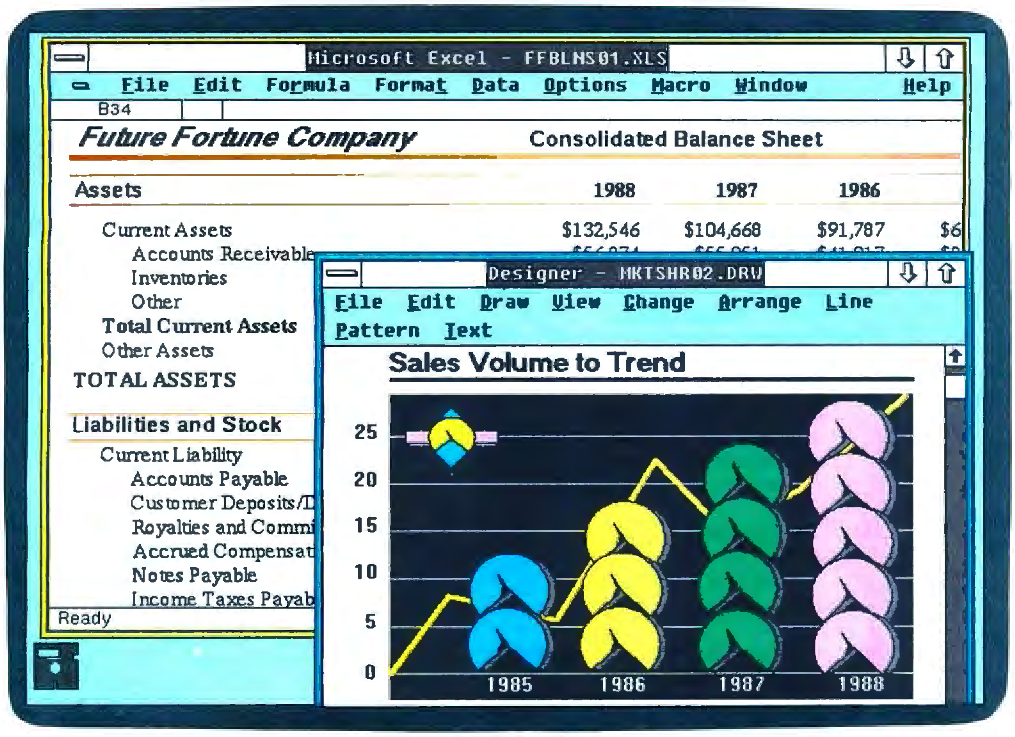

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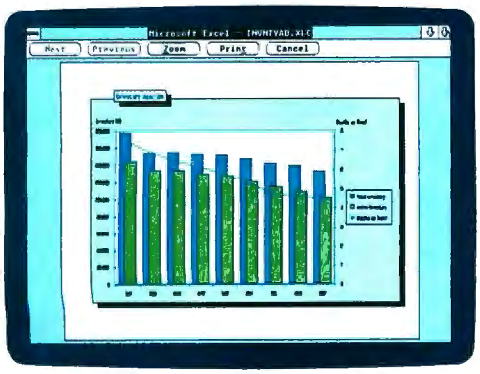

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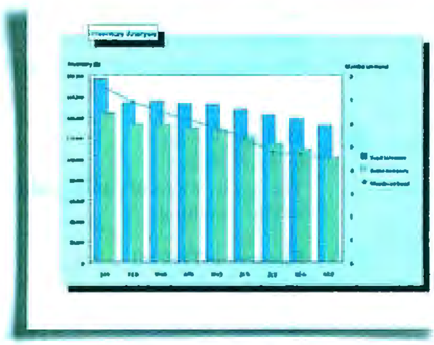

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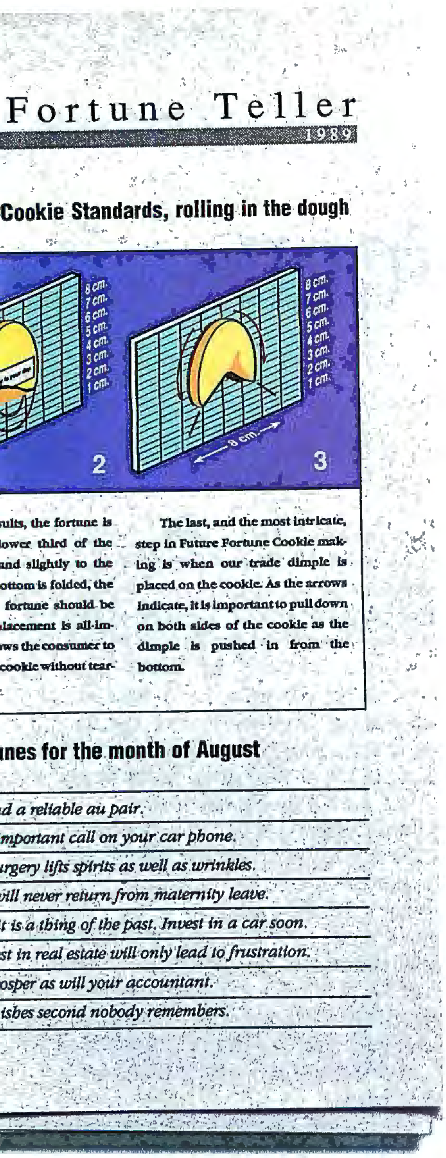

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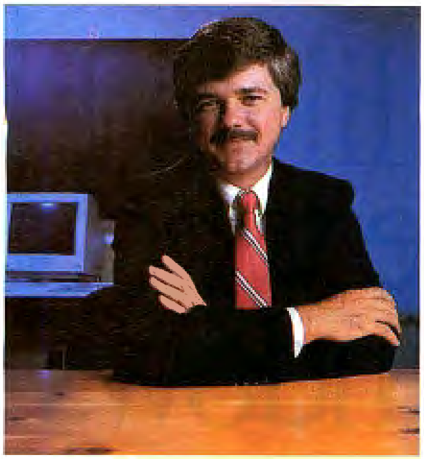


THE LAST WORD ON THE SX?

An 80386SX-based computer isn't necessarily cheaper than an 80386 machine, or faster than an 80286

At a recent trade show, I was part of a seminar designed to help attendees determine the relative strengths and weaknesses of the 80286, 80386SX, and 80386 chips.

It's a topic that won't go away. New SX machines appear almost every day, and confusion over just what 80286 machines can and can't do still runs strong.

Fortunately, a new tool will help sort out the confusion: the complete benchmark results of all the machines BYTE has tested. This compilation of results appears in BYTE's annual *IBM Special Edition*, which is now on sale. (The compilations also contain all our Mac benchmarks. But as the 80286/SX/80386 issue is Intel-family-specific, I'll stay on that side of the fence for now.)

It's instructive to pull out data comparing 80286, SX, and "true" 80386 machines from that mammoth list. For example, I'll focus on just one element: CPU performance.

The SX as an 80386

First, I'll look at how the SX stacks up against true 80386 chips (i.e., those not hobbled by the SX's 16-bit bottleneck).

True 80386 chips come in a variety of speeds. As of now, the SX is available in only one speed: 16 MHz. Clearly, the 20-, 25-, and 33-MHz 80386 chips will blow the doors off the SX, so I'll focus only on the slowest of the true 80386 machines: the 16-MHz units.

The SX machines we've benchmarked so far yield an average CPU index of 1.88 (where an 80286-based 8-MHz IBM PC AT equals 1). A sample of two dozen 16-MHz 80386 machines (mostly low-end clones) from our benchmark tables averages some 23 percent faster, with a CPU index of 2.33 (see the figure).

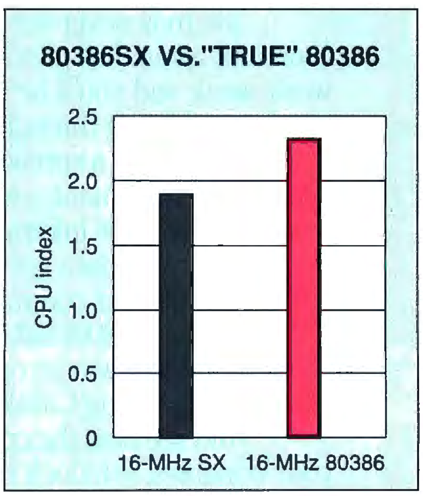
That's significant: Here are two types of 80386 chips, both running at 16 MHz, yet the full 32-bit version is 23 percent faster than its 16-bit SX cousin. Clearly, as an 80386, the SX comes up short. (Ironically, many low-end 80386 boxes cost less than their slower SX cousins.)

The SX as an 80286 Replacement

It's common knowledge that Intel first introduced the SX as a way to phase out the 80286. Thus, how does the SX stack up against 80286-based machines?

Well, 80286-based machines come in a wide range of speeds. Comparing SX machines to similarly clocked 80286 units shows no overwhelming advantage either way. They run roughly the same.

But wait, the 80286 is available in speeds of up to 20 MHz, with 25-MHz chips due soon. We took a look back at the benchmark results for the fastest available (20 MHz) 80286 and compared them to the fastest available (16 MHz) SX. (We used the older non-80386-specific BYTE benchmarks to make sure that the playing field was level.) The results were surprisingly lopsided: The fast 80286 units ran a whopping 36 percent faster than the SX machines. Wow!



Even at the same clock speed, "true" 80386 machines run an average of 23 percent faster than 80386SX machines. (In BYTE's CPU index, higher numbers are better.)

It's hard to see the SX as a particularly attractive replacement for the 80286, at least where raw speed is concerned.

So what's the SX good for?

Well, it's good for laptops, portables, and small-footprint desktop units. The prices of SX machines are dropping, and in settings where weight, size, and power consumption are the major considerations, the SX may prove to be an attractive alternative.

But for normal desktop applications, the SX is simply not a great choice. Yes, it will run true 32-bit software (e.g., DESQview/386 and Paradox 386), but the software will run more slowly than on most true 80386 machines, including many low-cost clones. For true 32-bit 80386 power, a full-blown 80386 machine is your only choice.

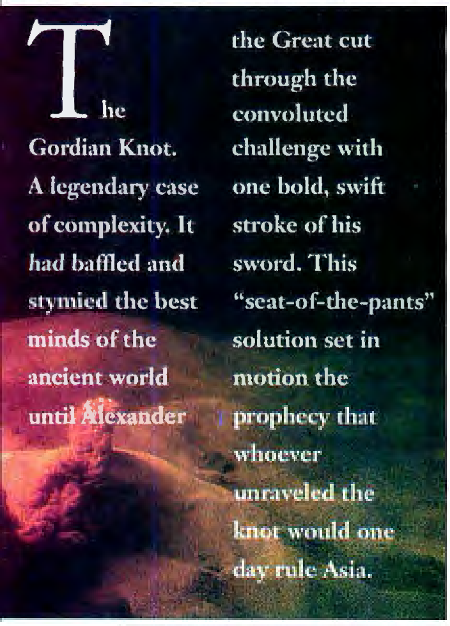
If you don't require a full 32-bit data path (say you want to run only today's DOS and OS/2 applications), a fast 80286—especially the 20- and 25-MHz units—will give you more speed plus full DOS and OS/2 compatibility. It should also cost less than today's SX machines.

Of course, in buying any machine, you need to look at the complete system: The world's fastest CPU can be turned into a snail if it's saddled with a sluggish hard disk drive or a slow video system.

The SX has its place. But so do the 80286 and the true 80386. Let an objective measure, such as benchmarks, sort out which is right for you.

—Fred Langa
Editor in Chief
(BIX name "flanga")

Smalltalk V



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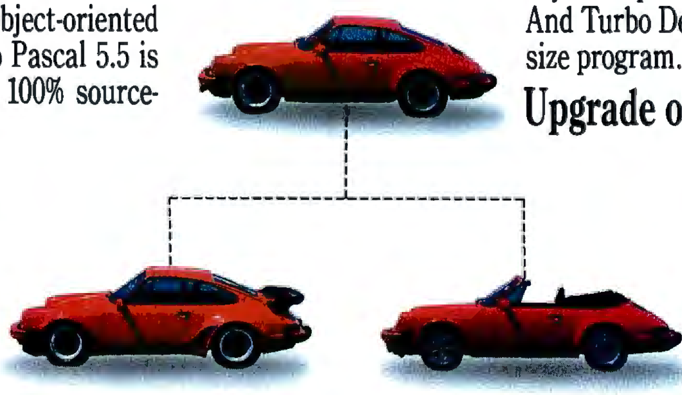

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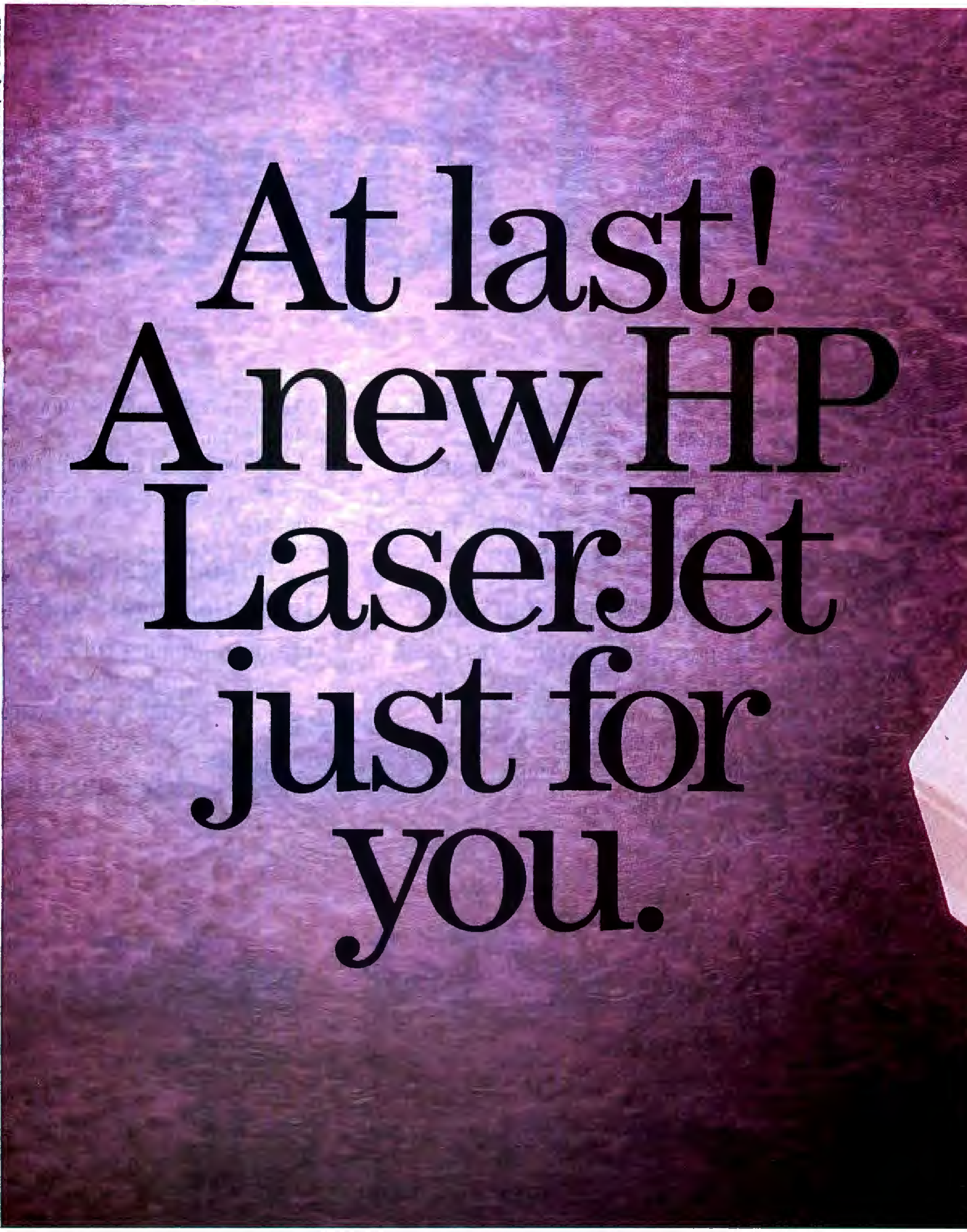

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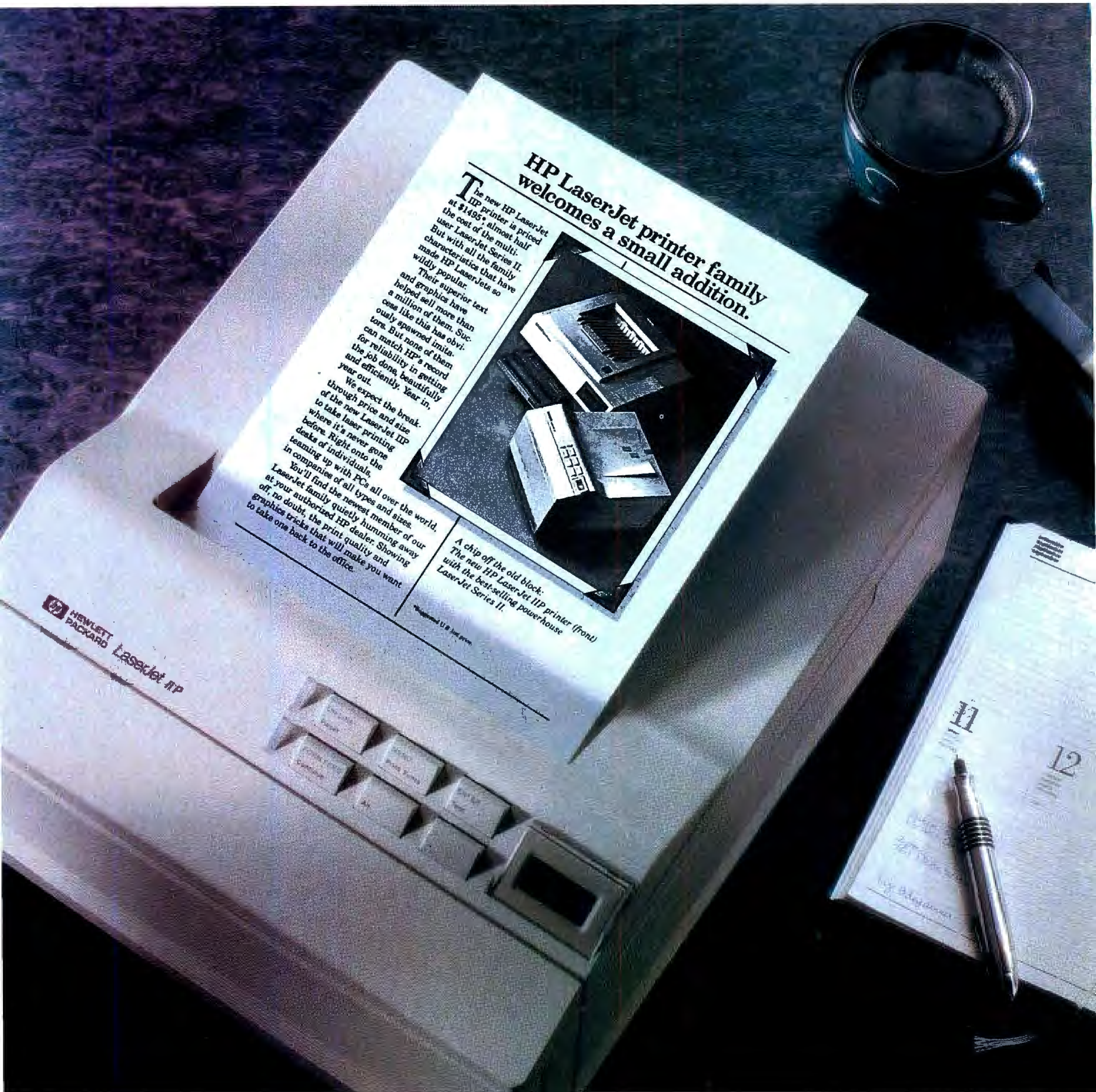

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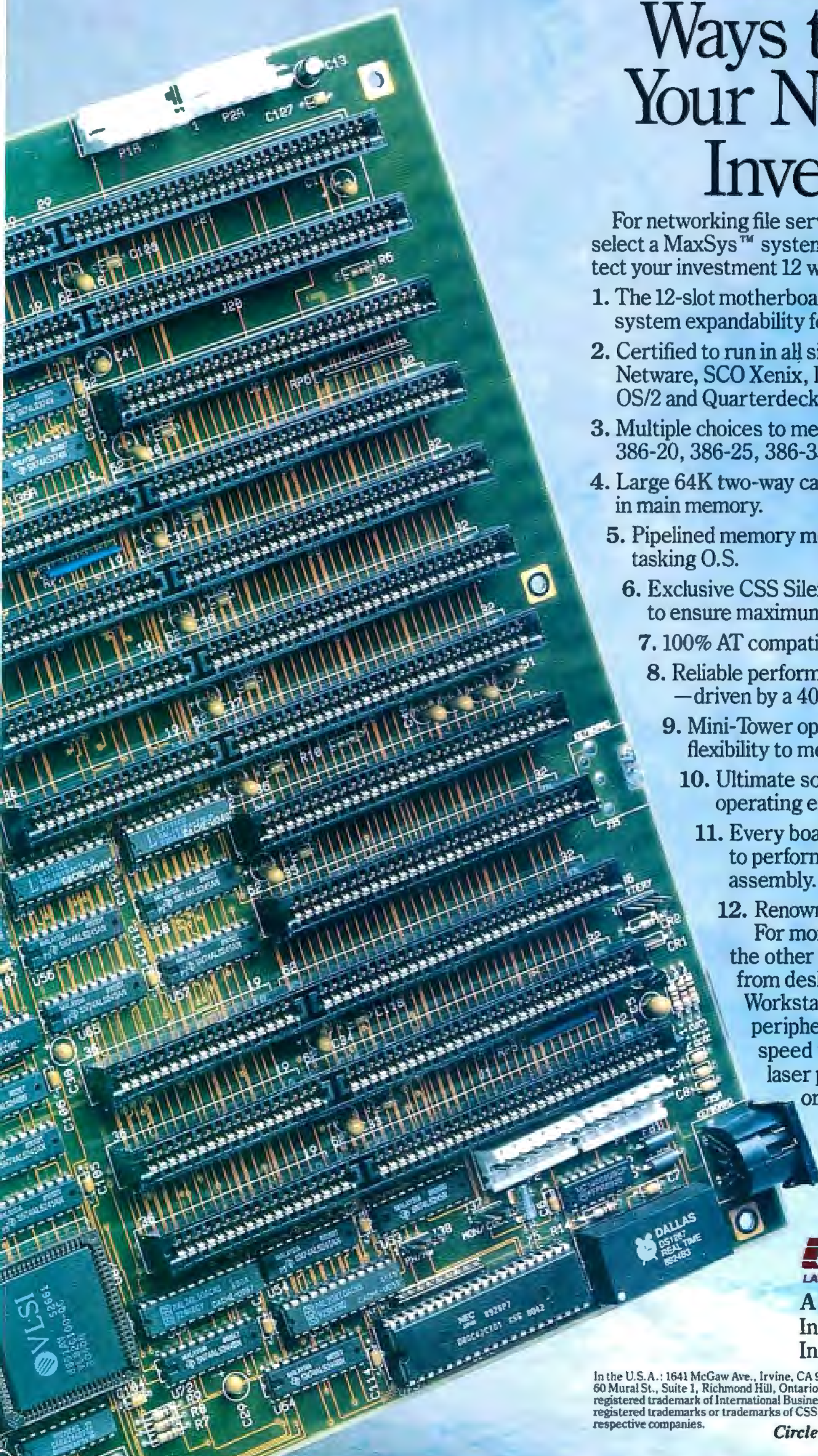

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Circle 91 on Reader Service Card (DEALERS: 92)

Staff-written highlights of developments in technology and the microcomputer industry, compiled from Microbytes Daily and BYTEWEEK *reports*

Will Clock Speeds Top Out at 50 MHz?

An issue that computer designers can't seem to agree on is the ultimate potential speed limit of microprocessor clock rates. The more conservative argument, put forth at the Microprocessor Forum by *Microprocessor Report* editor Michael Slater and several other conference speakers, maintained that clock speeds will top out at about 50 MHz, primarily because of the limitations of conventional packaging and circuit board design, as well as the limits of memory speed.

"The electrical environment becomes a real problem at clock speeds higher than 33 MHz," said John Theus, chief designer of the Tektronix XD88 workstation.

Former IBM Fellow Andrew Heller was decidedly more optimistic, predicting clock speeds of 100 and 150 MHz in the "next few years." Heller said new packaging techniques, such as "processor modules" and increased packaging density, would allow these higher clock speeds. Jim Peterson of Bipolar Integrated Technology said that his company is using bipolar technology to develop SPARC processors with a clock speed of 100 MHz.

Nevertheless, microprocessor experts agree that higher memory bandwidths (i.e., wider memory buses) would be needed to reach these higher levels of performance. MIPS Computer cofounder John Hennessy said that "64-bit address space is the next major architectural hurdle."

DEC's New Packaging Yields Denser Boards

Digital Equipment Corp. (Maynard, MA) has developed a new method for the electronic packaging of semiconductor chips that DEC says will yield processor boards with 30 times the density of the boards used in its VAX 8800 minicomputer. The packaging density determines the interconnect distances and thus the speed of signal propagation between ICs, DEC says. Signal propagation speed affects the cycle times of microprocessors and the data transfer rate between processors and memory. The typical signal propagation delays inherent in conventional printed circuit boards are a major obstacle to advances in processor performance.

DEC's new packaging technology, developed at the company's facility in Cupertino, California, consists of three main components: the High-Density Signal Carrier (HDSC), the Multi-Chip Unit (MCU), and the Planar Module, which connects multiple MCUs into a single system board. The HDSC performs the same function as a conventional board but allows circuit densities three to five times greater, DEC says. Using emitter-coupled-logic (ECL) devices, the logic of the four 15- by 12-inch boards of the VAX 8800 is represented on a single 4-inch-square HDSC—meaning a 30-fold increase in packaging density—according to DEC.

The HDSC is a nine-layer package on a substrate of polyimide-copper with a finished size of 4 inches on a side. Typical propagation delay on the HDSC is 160 picoseconds per inch, versus a delay of about 200 ps per inch on traditional boards, DEC says. The HDSC supports a range of chips, including ECL gate arrays and self-timed RAM chips developed by DEC. Power distribution and termination circuitry are built directly into the HDSC, eliminating the need for separate diodes, resistors, and decoupling capacitors.

The HDSC package mounts on the MCU, which can support up to 72 VLSI chips and has 800 I/O connectors (200 connectors on each side, 100 of which are ground connectors). Multiple MCU packages can be mounted onto the planar module, which is an advanced version of a printed circuit board. DEC officials displayed a 24- by 24-inch planar

continued

NANOBYTES

Intel will bring out a **50-MHz** version of its **80486** this year, according to the man they call the "chief architect" of that processor, John Crawford. Ten years from now, Crawford predicts, we can expect the "Intel Micro 2000," a processor that will consist of 50 million transistors and, he promises, will be compatible with the 80386. (The BYTE News and Technology Department hereby announces its Micro 2000–based pocket-size workstation, making us the very first to introduce a system based on the forthcoming chip.)

Before the flood: Speaking of what's ahead, **80 80486-based systems** are currently on the drawing boards in **Taiwan**, according to an Intel official. There are **400 80386-based machines in the works** there, he said.

So how are the makers of more expensive personal computers going to separate their systems from the herd? Can you say **multimedia**, boys and girls? "Multimedia is a way for the truly value-added PC makers to distinguish themselves," said Bob Brannon, of **Intel**'s Princeton (NJ) Operations, at a recent conference. Brannon works on Intel's Digital Video Interactive project, whose aim is to "get TV into the PC in an interactive fashion." TV-in-a-PC is something that the low-cost cloners can't afford to offer, he said.

PC fax boards could soon be exchanging binary files at 9600 bps. A binary-transfer standard for fax boards "is getting nailed down," according to George Masters, president of fax-board maker **Fremont Communications** (Fremont, CA). Some boards have a "peer to peer" binary transfer capability by which they can ship files to other boards of the same make, but there's no industry file transfer standard.

NANOBYTES

The Library of Congress's collection of 88 million printed and recorded items could someday be available on a **national information system**, if the government approves an advanced communications network proposed by Senator Albert Gore (D-TN). "Thousands of books could be on-line, available at the touch of a button," Gore said at a senate hearing recently. James Billington, the chief librarian for the Library of Congress, envisions citizens being able to go to their local library and browsing through the Library of Congress's resources via computer. Gore's proposal would create a **National Digital Library** of unclassified federal data banks and software libraries.

Some citizens at 1600 Pennsylvania Avenue are also backing establishment of a national computer network. The **White House Office of Science and Technology** has proposed setting up a National Research and Education Network, linking 1000 research sites around the country and capable of transmitting material at speeds comparable to sending 50,000 single-spaced typed pages in 1 second. "A future national high-speed network could have the kind of catalytic effect on our society, industries, and universities that the telephone system has had during the twentieth century," said OST head Allan Bromley in a letter to Congress.

Sun Microsystems (Mountain View, CA) has opened up its **SBus** to other companies for building add-in boards or computers. The SBus, which made its debut last spring in the SPARCStation, is capable of transferring data at 80 megabytes per second, Sun says; that makes it about twice as fast as the NuBus and the Extended Industry Standard Architecture bus. **Paul Borrill**, former National Semiconductor executive who helped develop the FutureBus specification and now works for Sun, emphasized that the SBus is "not specifically a system bus" but rather a "modular I/O interconnect," or a "mezzanine bus" that can coexist with other buses.

module containing 16 MCUs.

DEC has no plans to license its new packaging technology to other systems manufacturers. The new packaging will appear in a wide range of upcoming products from DEC, according to John Manzo, manager of systems software engineering. Other companies have been working on similar wafer-scale integration of circuits. IBM has developed a liquid-cooled thermal conduction module that uses tiny thermally controlled bumps to connect circuits. Siemens and NEC are reported to have projects under way involving ceramics and high-density packaging. But DEC claims to be the first to have this technology ready for commercial use. At this point, though, it's not clear to what extent the packaging method will increase performance.

New Battery Could Last a Laptop's Lifetime

By the mid 1990s, your laptop computer could be powered by batteries that weigh one-fifth the weight of current cells, run for days before they need to be recharged, and last longer than the computer itself. And your desktop computer could have a built-in backup power supply the size of a couple of packs of cigarettes. The promise of these lightweight, long-life power cells comes from technology being developed by a young company called Moltech Corp. (Shoreham, NY).

Moltech is developing thin-film batteries based on solid conducting polymer electrolytes instead of the more conventional (and corrosive) liquid electrolytes used in most of today's batteries. Batteries based on liquid polymer electrolytes already exist, but they work only above 80 °C, obviously limiting their utility in most applications. But Moltech scientists expect their solid solvent-free batteries to work at room temperature and below. Solid polymer batteries will be based on anionic groups (usually vanadium oxide or titanium sulfide) attached to a polymer "backbone."

Polymer batteries will have several advantages over current lead-acid and nickel-cadmium cells, Moltech president Terje Skotheim says. In addition to five times greater power storage capacity per weight or volume, they'll have a charge/discharge cycle of more than 1500 cycles (as opposed to about 200 for current batteries), he says.

But the most intriguing thing about polymer batteries is their potential for ultralong life. They're expected to lose only 1 percent of their power capacity each month, Moltech says. Conventional batteries lose up to 30 percent per month while in use. "These batteries will outlast most devices that they power," Skotheim claims.

Because the batteries will be manufactured in polymer sheets, it should be easy to make cells of different sizes and capacities. For example, a tiny battery for a calculator could be made by "cutting off a small corner of the polymer sheet," according to Skotheim. A large-capacity battery for a backup power supply would result from "rolling up the polymer sheet."

Skotheim says polymer batteries will be less expensive to manufacture than conventional cells, but because of their size and expected longevity, they're likely to fetch a hefty premium in their initial incarnations.

But it will be a while before you'll be able to buy a lightweight, long-life battery for a laptop computer. Moltech doesn't plan to have a functioning prototype ready until "late 1991" at the earliest. And consumer applications probably won't be available until several years later.

New Titles Show Diversity of CD-ROM

We'll know that the CD-ROM market has matured when we need a CD-ROM just to list all the CD-ROM titles. Until then, we can gauge the market by the types of titles that make it to disk. Judging by recent releases, the CD-ROM catalog is diversifying. Here's a sampling of some new platters.

Meridien Data (Scotts Valley, CA) has compiled hundreds of images sent back to Earth by the Voyager and Viking planetary probes. The GRIPS

continued

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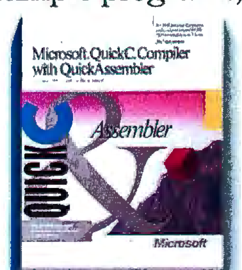

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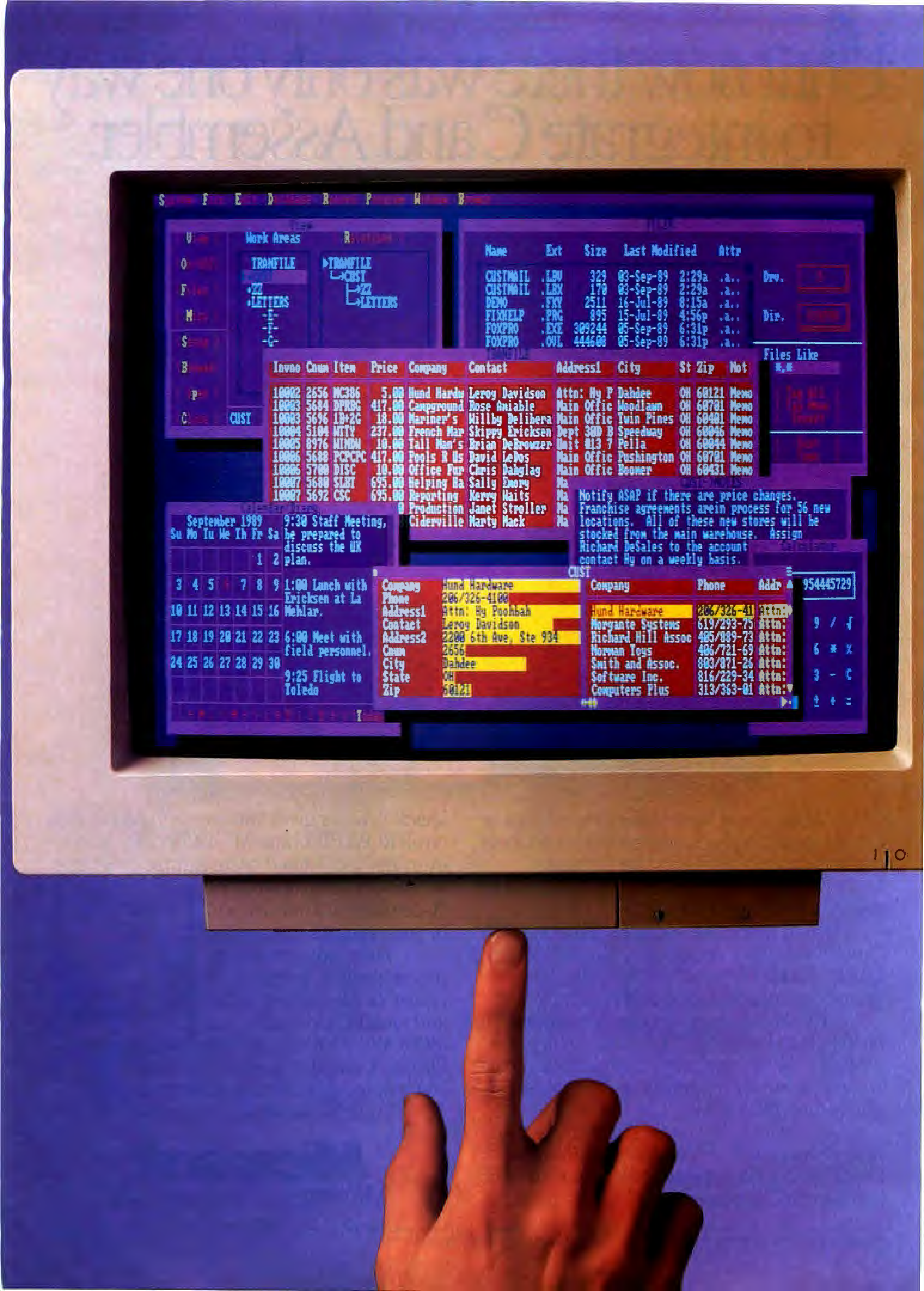
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NANOBYTES

Solbourne (Longmont, CO) and **Matsushita Electric** of Japan are collaborating on a **64-bit SPARC** processor with a 40-MHz clock speed, said Solbourne's vice president of engineering, Mike Schumacher. Like other new chips, the Solbourne SPARC processor will include integrated integer and floating-point processors, separate instruction and data caches, and on-chip memory management. The chip will contain 1 million transistors and will measure only 15 millimeters on a side, Schumacher said. Solbourne plans to introduce a workstation based on the new processor in mid-1990.

Sybase (Emeryville, CA) has developed a specification for networked **communications between diverse database applications**. As an "open" standard, the Open Server application programmer interface will enable developers to create a server-based front end for non-Sybase databases and applications, the company says. This would allow minicomputer and mainframe databases (e.g., DB2, RMS, Oracle, and Ingres), other large-system applications, and real-time data feeds to be transparently accessed by any client or server application that supports the format. Open Server object code is slated to be released for Unix and OS/2 machines next year, Sybase said.

NIPS, not MIPS: Computers designed specifically to move data on and off networks will replace plain old computers as servers, says a new study from **Forrester Research** (Cambridge, MA). The report says this new breed of network computer will employ multiple buses, intelligent I/O subsystems, and multiprocessing capability to provide faster throughput than is possible with a standard computer; they'll also have redundant power supplies, backup components, and error-correction facilities. Instead of millions of instructions per second (MIPS), Forrester researchers say, these systems will be gauged by a new measurement: network I/Os per second, or NIPS.

(Government Raster-Image Processing Software and Data) disk contains photos of Mars, Jupiter, and Saturn, but not the recent photos of Neptune. Meridien concedes that it's not easy to find a specific image from among the hundreds on the disk but says it is trying to make the compact disk more user-friendly. The $9 CD can be viewed with a Macintosh- or IBM-compatible drive.

Encyclopaedia Britannica (Chicago) has put all 26 volumes of Compton's Encyclopedia (31,200 entries) onto a CD and has added "multimedia" enhancements, such as color and black-and-white illustrations, sound (e.g., famous speeches and snatches of music), and animated sequences. Hypertext mechanics let you jump topics or delve further by clicking on words and icons. Compton's Multimedia Encyclopedia should be released next month at $895 ($795 for schools and libraries); it will work with IBM-compatible drives from Sony, Hitachi, and Amdek.

Wondering about that diet of Teenage Mutant Ninja Turtles cereal and Jolt Cola? The Food/Analyst from Hopkins Technology (Hopkins, MN) is a database of 5000 foods and 80 nutrients, including fast foods and breakfast cereals, that the company says can adapt to a user's eating habits and provide nutritional evaluations.

For companies doing business with the U.S. government, Optical Publishing (Fort Collins, CO) has put together Farsearch, a database containing the complete Federal Acquisitions Regulations and list of Department of Defense FAR bases.

Need a fax number? If it's listed anywhere in the world, or if there's a telex number, Jaeger + Waldman Publications (Bethpage, NY) says you can find it on the J + W Commdisc.

Quanta Press (St. Paul, MN) is like one of those mail-order music houses that stock everything from Big Bill Broonzy to Yma Sumac. The company distributes an eclectic range of disks, some compiled by other publishers. The latest additions to Quanta's catalog include The World Factbook, an annual almanac compiled (and unclassified) by the Central Intelligence Agency; Dick's Some of the Earth's Planes, a visual digest of aircraft; Seals of the Government Printing Office (official emblems of federal agencies like the Railroad Retirement Board); Shareware Gold, a collection of shareware programs; and About Cows, a compendium of information on our bovine friends.

And one of the most browsed books in the world, the *Guinness Book of World Records*, has been adapted to CD-ROM by Pergamon Compact Solution (London) and Knowledge Set Corp. (Mountain View, CA). The company has added color photos, sound effects, animation, and music to this annual assemblage of data. To page through the $99 Guinness Disk of Records and find out who holds the world record for pizza consumption, you'll need a Macintosh with a CD-ROM drive and HyperCard 1.2 or higher.

Compiler Optimization, Parallelism Hold Keys to Improving Processor Performance

To make the next leap forward in microprocessor performance, designers will have to improve compiler optimization and make better use of parallelism, according to experts gathered at the Microprocessor Forum in San Jose, California.

There is "real opportunity" in better compiler technology, with possible three- to fourfold performance improvements as a result, said Stanford University professor and MIPS Computer cofounder John Hennessy. The challenge is to enable compilers to recognize microprocessor operations that can be executed in parallel, rather than sequentially. Parallelism is inherent in simultaneous integer and floating-point operations. With modern microprocessors now integrating floating-point and integer units on a single chip (e.g., Intel's 80486 and Motorola's 68040), developers must now update compilers to take advantage of this new level of integration, Hennessy said. Most compilers currently on the market cannot perform parallel floating-point and integer operations.

Andrew Heller, industry consultant and former IBM Fellow, agreed with Hennessy's view, saying that compilers must be designed "to recognize parallelism." He also said that compilers could benefit from better

continued

Welcome to the Real-World.

instruction scheduling techniques. "The biggest inhibitor [to improved performance] is the lack of software tools," said Heller.

"Parallelism is a key concept," said IBM's director of engineering for workstations, Phil Hester. "Compilers have to be able to dispatch multiple instructions in a given cycle."

Although the Microprocessor Forum is essentially a hardware conference, several speakers emphasized the importance of software in taking processor performance to the next level. Indeed, there was a grain of pessimism among the speakers in predicting future performance gains. Hennessy was not optimistic about the progress of multiprocessing, saying that it will be the late 1990s before multiprocessing systems actually come to market. "We have underestimated the complexity and system architecture problems" associated with multiprocessing, he said, a sentiment echoed by other conference attendees.

The old problem of binary compatibility is another obstacle to performance improvements. According to Intergraph's technical marketing manager, Harley McGhan, designers of the first RISC processors were able to make major performance gains because they started with a clean slate; they didn't have to worry about binary compatibility with earlier generations. However, upcoming RISC chips will have to maintain binary compatibility, and this will limit the degree of performance improvements.

The annual Microprocessor Forum is organized by the *Microprocessor Report* newsletter and its editor, Michael Slater. You can order audiotapes of the proceedings by writing to Slater at *Microprocessor Report*, 550 California Ave., Suite 320, Palo Alto, CA 94306.

New ROM DOS Frees Space for Applications

Microsoft (Redmond, WA) has developed a version of MS-DOS that executes in the computer's ROM rather than in RAM. The company is aiming the ROM-executable DOS at makers of laptop computers and embedded systems—Poqet Computer, for example, is using ROM MS-DOS in its hand-held PC. Several computers come with DOS in their ROM chips, but they first load the operating system into RAM.

The main advantage of ROM-executable DOS is that it saves approximately 40K bytes of RAM, which is then available for other applications. Designers of embedded systems will be able to build DOS directly into the hardware and then will be able to run MS-DOS applications. The ability to build MS-DOS into embedded applications will make it easier to develop software for those systems, according to Microsoft product manager Mark Chestnut.

ROM-executable DOS is "preconfigured" in the host computer system, thus eliminating boot procedures from disk or time delays while the operating system loads into RAM.

Microsoft had to significantly rewrite MS-DOS to make it ROM-executable, program manager Tom Lennon told BYTE. "We had to completely reorganize the segmentation areas in memory," said Lennon. The ROM version is actually a "split system," using small portions of RAM for accessing "modifiable" data, such as the file structure, he said.

Microsoft will supply a "binary adaptation kit" to OEM licensees, which includes the code and instructions necessary for "burning" MS-DOS into the OEM's ROM chips. Emerson Radio Corp. and Headstart Technologies have licensed the product. Vadem Corp. will distribute ROM DOS for its Intel 80186-based embedded processor systems.

INMOS Cuts Cost of MIPS to $2 Each

INMOS has designed a low-cost version of its 32-bit T425 processor that the company says is capable of 10 million instructions per second at 20 MHz; at a volume price of $20 each, this translates into a price/performance level of $2 per MIPS, INMOS says. The new T400 has a full 32-bit integer-only CPU but no floating-point unit. It is fully software-compatible with other transputers.

continued

NANOBYTES

Maxem Corp. (Tempe, AZ) is now offering **Cause**, its object-oriented programming software, in a package that contains a version for IBM compatibles and a version for Macintoshes. The new mixed-environment edition is priced at $495, which is what the PC- and Mac-specific versions used to sell for; those editions now cost $295. Cause is designed to let users develop custom applications **without learning a programming language**; instead, you pick and choose icons that represent functions.

Shareware collections were the **best-selling CD-ROMs** in 1989, according to a top-10 list compiled by the **Bureau of Electronic Publishing** (Upper Montclair, NJ), a disk distributor. Shareware Grab Bag (Alde Publishing) and PC-Sig Library (PC-SIG) sold more copies than Grolier's Encyclopedia (which was number one in 1988), Microsoft Bookshelf, Microsoft Programmer's Library, McGraw-Hill's Science & Technology Reference, and the Oxford English Dictionary, the company says.

One of the first things people notice about the little Zenith MinisPort computer is its use of **2-inch floppy disks**. "Cute," they say. "But where will I be able to buy them?" When Zenith introduced the MinisPort, no one was selling 2-inch floppy disks for computers (Sony and others were using them in electronic cameras). But now **Memorex** (Santa Clara, CA) is making the teeny floppy disks for use in computers. They're compatible with current floppy disks and can store 1 megabyte of data.

More than 30 companies involved in establishing a standard for **FDDI** (Fiber Distributed Data Interface) LANs have formed the **Advanced Networking Group** to investigate interoperability between products from different vendors. The ANG roster includes **Advanced Micro Devices** (the initial sponsor), Hewlett-Packard, AT&T, Sun, Ungermann-Bass, and Sony. The group's first task is setting up the Interoperability Test Center.

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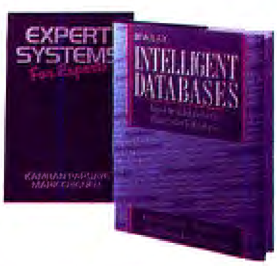

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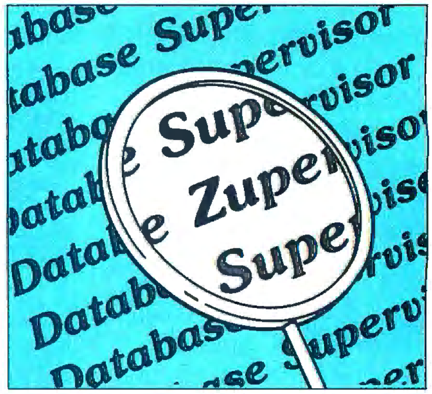
The Intelligence/Compiler is a powerful state of the art system for real-world applications. Its intelligent editing and debugging facilities are a bonus. *AI/Expert Magazine*, February 1988.

Considering the variety of features that the Intelligence/Compiler provides, it is hard to believe that you can get better value for your money. *PC/AI Magazine*, June 1989.

Having used IXL on a large database of geological test data, we were surprised by the many relationships it found. This has greatly helped us to interpret our Oil Company database. *Mr. James Brown*, Oil Industry Consultant, July 1989.



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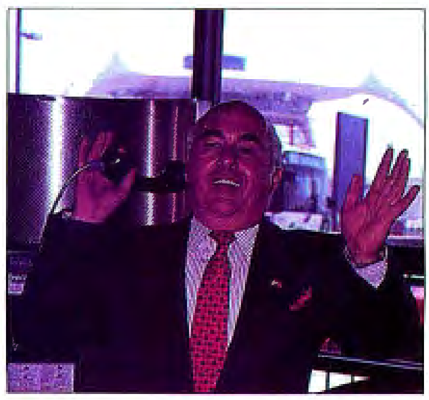

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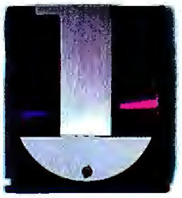
The Next Level in Computing

Circle 162 on Reader Service Card

1 The NeXT™ Computer System is the first computer in the world (and so far the only) to use read/write/erasable optical storage. While PCs today are typically equipped with Winchester drives that store 20 to 40 MB, a single optical disk can store 256 MB. Plus, it is removable, for portability and added security.

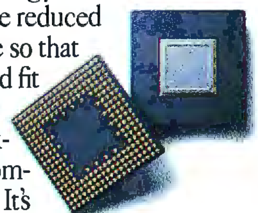


This dramatically new technology provides storage that is simultaneously vast, reliable and cost-effective—a combination unmatched by computers of any size.

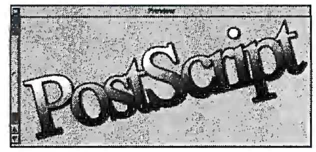
2 NeXT has made the power of UNIX® usable by mere mortals. UNIX is the high-performance operating system used by workstations to achieve true multitasking and superior networking. Unfortunately, it has

always been the antithesis of user-friendly. NeXT has given UNIX a revolutionary new interface—one that is both visual and intuitive. Now computer users of every level can instantly wield this tremendous power, with no technical knowledge whatsoever.

3 To achieve the power needed for the 90s, NeXT bypassed traditional workstation architecture and went directly to that of a mainframe. This eliminates bottlenecks and attains an extraordinary level of system "throughput"—the true measure of computer performance. Only through the use of VLSI (Very Large Scale Integration) technology could this architecture be reduced in size so that it could fit inside a desktop computer. It's a mainframe on two chips.



4 While PostScript® has long been the industry standard for printing, NeXT has made it fast enough to also be used on the display. This "unified imaging model" ensures that what you see on



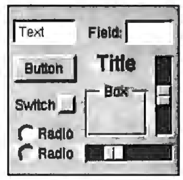
the display is precisely what you will get on paper. All your work, in any size type and any degree of rotation or magnification, appears with perfect 92-dots-per-inch clarity on the NeXT MegaPixel Display. And with laser precision at 400 dpi on the NeXT Laser Printer.

IN THE 90s, WE'L
ONLY TEN REAL BREAKTH
HERE ARE SEV

5 The NeXT Computer System is the first to be capable of producing CD-quality sound. Without requiring any additional equipment. This feat is made possible by a chip that has been specifically designed for the task of manipulating sound—the Digital Signal Processor (DSP). Because this processor is standard in every NeXT machine, software developers will be able to call upon its power to enrich programs we use every day. Now computers will not just be seen, but heard.

6 NeXT Mail takes electronic communications beyond anything you've seen on a personal computer before. Now you can send and receive multimedia mail—including text (with varied type fonts, styles and sizes), graphics and voice messages. And despite its high level of sophistication, NeXT Mail is so intuitive, you may not ever need to open the manual. NeXT Mail is built into the system, along with Ethernet and TCP/IP, so the NeXT machine can quickly become a part of existing networks.

7 Programmers can create software on the NeXT Computer up to ten times faster than on any other computer—the result of a breakthrough called NextStep.® It gives software developers the power to create the graphical user interface portion of their applications (often the most time-consuming and difficult part) without any programming at all. This revolutionary environment means we will see more programs, and better ones, in less time than ever possible before.



These seven breakthroughs will change the way we use computers in the 90s. Which is why Businessland, the leading supplier of computers to corporate America, chose the NeXT Computer System as the workstation they will offer. Call us at 800-848-NeXT, and we'll send you a 28-page brochure describing the NeXT Computer. We'll also give you the address of your nearest Businessland Center. There, you can experience for yourself the first seven breakthroughs of the 90s. And get a good idea where the next three will come from.

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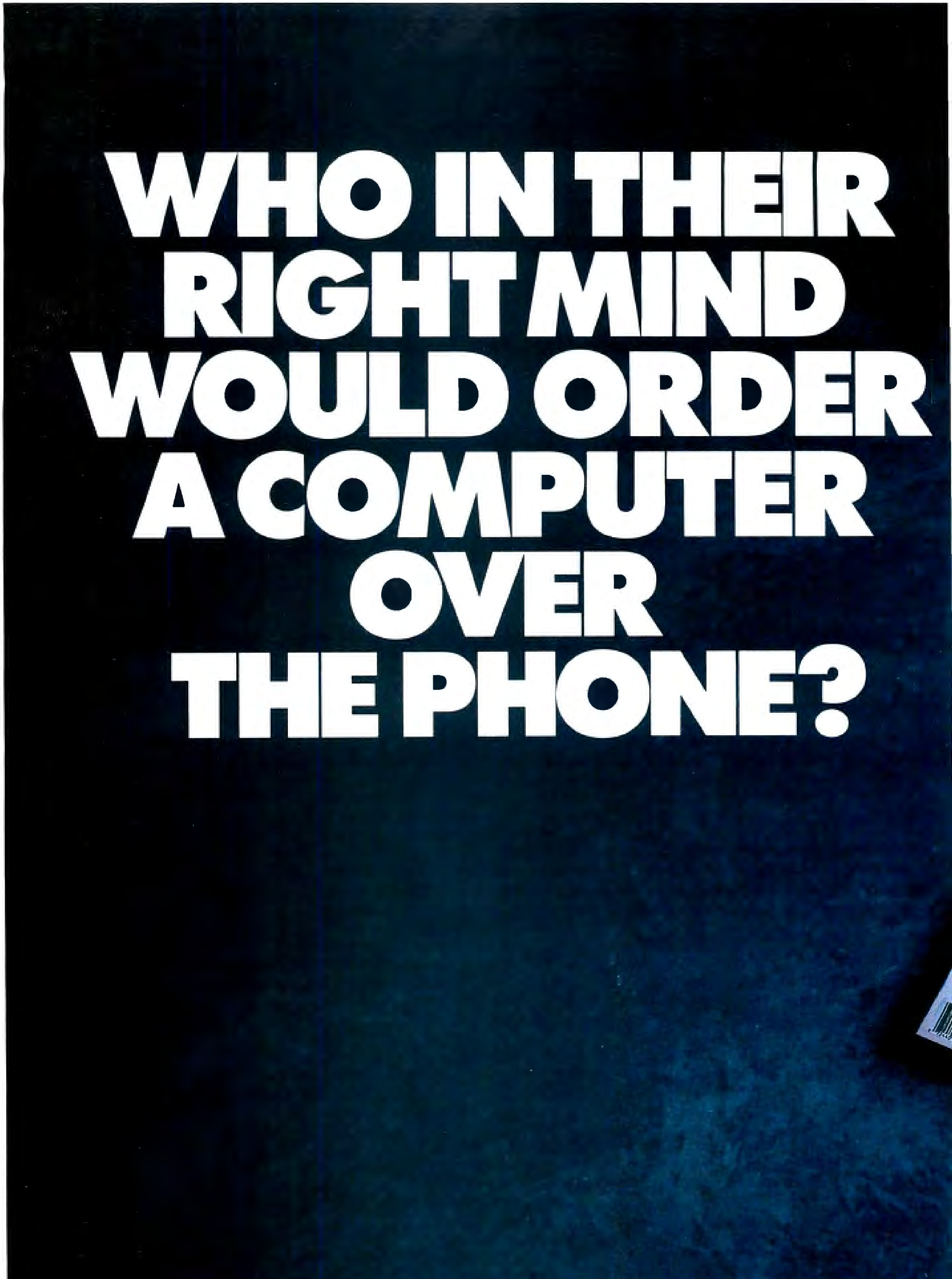
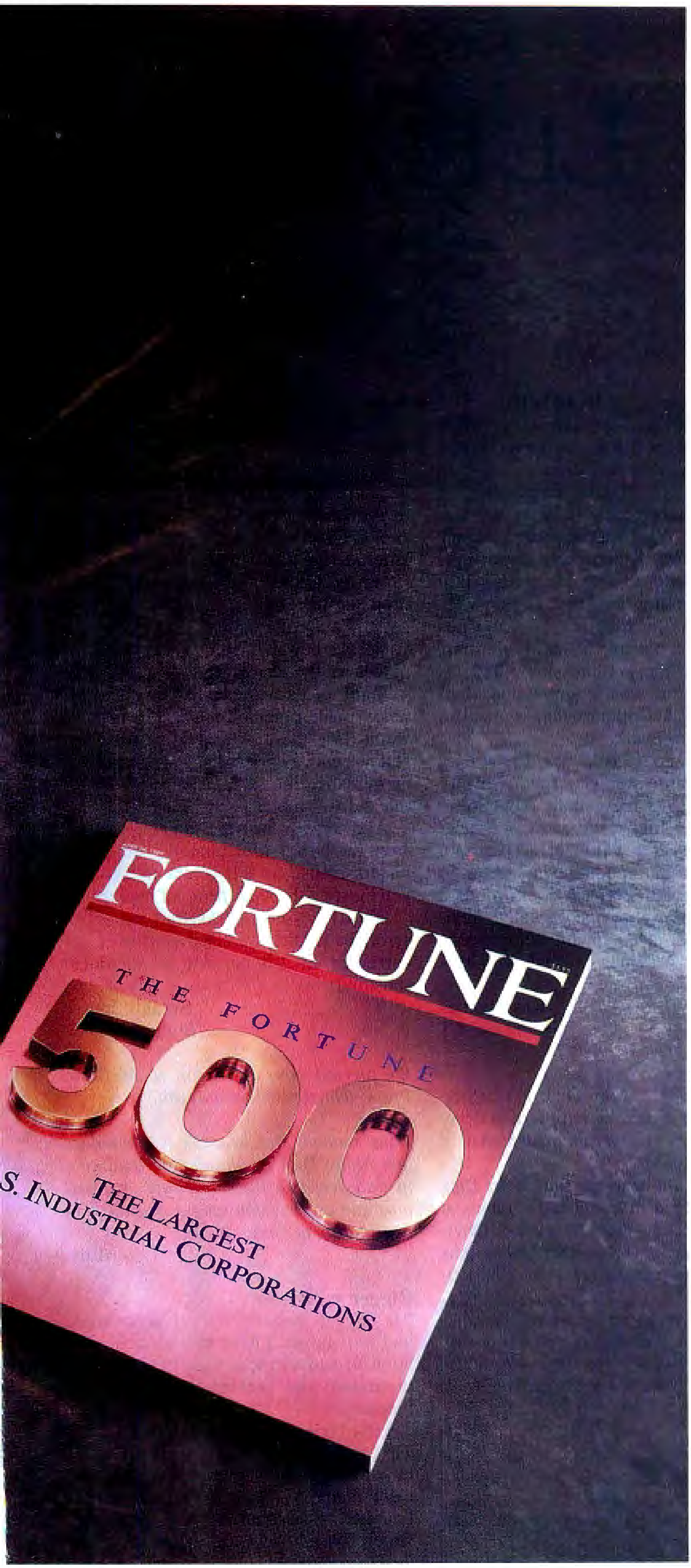
ROUGHS IN COMPUTERS.
EN OF THEM.

Circle 230 on Reader Service Card


WHO IN THEIR
RIGHT MIND
WOULD ORDER
A COMPUTER
OVER
THE PHONE?



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So when it comes to buying personal computers, they scrutinize such things as reliability, compatibility, performance, price and, oh yes, support.

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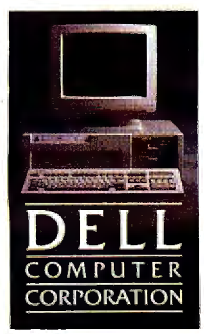

A process that not only saves you the 35% retail markup but 100% of the aggravation.

Which might prompt one to ask an even more relevant question: Who *wouldn't* order a computer over the phone?

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NANOBYTES

IBM shaved 5.8 percent off the price of three PS/2 models and pruned the price of one by 20 percent. The 8086-based Model 30-021 now costs $2255 (it was $2395); the 80286-based Model 30-E21 now costs $2445 (it was $2595); and the big 80386-based Model 80 with a 314-megabyte hard disk drive now costs $11,295 (it was $11,995). The biggest cut came to the Model 70-121, an 80386-based box with a 120-megabyte hard disk drive; it now lists for $6395 instead of $7995.

Citing drops in the cost of memory chips, **AST Research** (Irvine, CA) took a chainsaw to the price of its 1-megabyte RAMpage PC board. The memory-expansion card now has a price tag of $695; it used to be $1245. AST also trimmed the price of its VGA cards; the 8-bit AST-VGA now costs $399 (it was $445), and the 16-bit AST-VGA Plus is now $449 (it was $599).

After a successful trial test, the **National Institute of Standards and Technology** (Gaithersburg, MD) is proposing that **ISDN** be part of the Government Open Systems Interconnection Profile. As of August 1990, federal agencies cannot buy certain telecommunications or network products unless they conform to GOSIP. NIST wanted to make sure ISDN and GOSIP can get along together before suggesting the former be a part of the latter.

Meanwhile, at Interop '89 in San Jose, CA, a group of vendors staged a demonstration of IBM PC applications running over an **OSI network** through a NetBIOS interface. In theory, this all means computer users will be able to communicate with a wide variety of systems based on different architectures.

Aldus (Seattle) says that PageMaker for OS/2 1.2 will support mainframe graphics files (CGM and GDDM/PIF) and will be able to drive Hewlett-Packard's LaserJets. The company expects to release sometime in early 1990 a **Russian version** of PageMaker.

INMOS says that it reduced the cost by having only two instead of four on-chip serial links and by including only 2K bytes instead of 4K bytes of on-chip memory.

The company hopes that the low price will encourage the use of several transputers in parallel, even in volume products like fax machines or PostScript printers.

INMOS says that its next generation of transputer chips will be drastically faster, will incorporate a large cache, and will be able to run standard operating systems more efficiently. The processors will be capable of performing 100 MIPS and 20 million floating-point operations per second, said INMOS technical director Peter Cavill in London. The new chip, currently called the H1, will not be available until 1991, he said.

The serial links on H1 will be speeded up to 100 megabits per second full duplex, Cavill said, but the most radical feature of the H1 will be its support for "virtual links"; an on-chip packet network controller will multiplex messages onto links transparently so that a user program sees as many links as it needs, rather than the four fixed links of the current transputers. This could simplify the writing and configuring of parallel programs and could make programs easily portable among parallel computers of different topologies.

The network controller will also be able to "through-route" messages destined for other processors without any computational overhead. In turn, this should improve the performance of communication-intensive algorithms.

INMOS will add a hardware memory protection/management unit to allow standard operating systems like Unix to be run efficiently. The new design will also incorporate a DRAM controller that supports static column modes for fast RAM access. Some observers see these changes as INMOS's response to the Intel 80860 RISC processor.

Claris Aims to Ease Cross-Platform Transfers

Macintosh software maker Claris Corp. (Santa Clara, CA) is planning a common architecture for all its applications that the company says will make it easier to transfer files to and from computers of different makes. The company says that its new XTND (pronounced "extend") will enable software developers to create file translators that work with Claris products. XTND will let users directly import and export word processing, graphics, database, and spreadsheet files across multiple platforms, Claris claims. And because XTND will be common to all Claris applications, file translators will work with all Claris software; all that the Mac user will have to do is copy the appropriate translator file into the System folder, according to Claris.

MacWrite II 1.1 is the first program to incorporate XTND. The program supports 30 file-translation formats and allows you to transfer data files directly with many Mac, IBM, mainframe, and minicomputer applications, the company says.

Instead of using a file-translation utility to convert your, say, WordPerfect PC 5.0 file to the MacWrite II format, you select the Open command from the MacWrite menu, and XTND automatically translates the WordPerfect PC document to MacWrite format. Conversely, you can save a MacWrite II 1.1 file in up to 30 different formats and then put IBM PC (and other) files directly into MacWrite II documents, according to Claris officials.

Claris plans to license the XTND developer's kit at no charge. The idea is that developers can create a translator file specific to their application's file format; this assures that Claris XTND applications can read and write data files of that format.

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The BYTE news staff is always interested in hearing about new developments that might affect microcomputers, the way they work, or the way people work with them. If you know of a project that could shape the state of the art, please give us a call at (603) 924-9281 or write to us at One Phoenix Mill Lane, Peterborough, NH 03458. An electronic version of Microbytes, offering a wider variety of computer-related news on a daily basis, is available on BIX.

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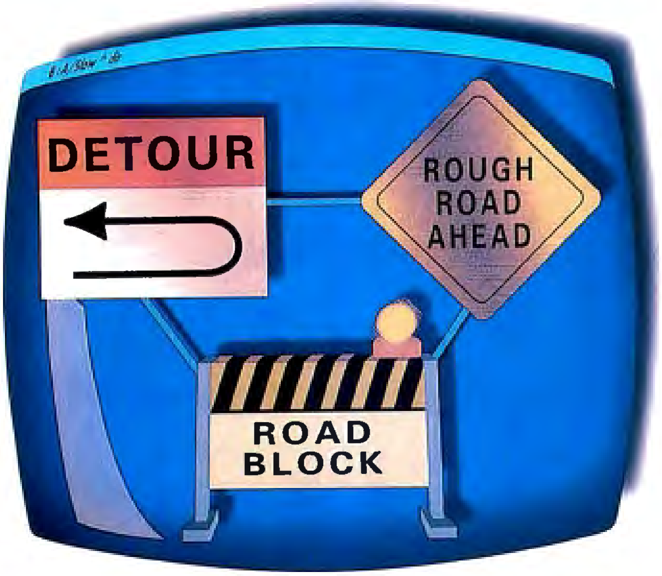

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LETTERS

and Ask BYTE

Data Compression Drawbacks

The 2400-bps modem evaluation ("4800 Bits, No Errors," June) was excellent; I was gratified to see some discussion given to the role of data compression. A very important question, however, was overlooked: What happens when you try to send already compressed data (e.g., .ARC files) to another computer via a data-compressing modem? The answer, I'm afraid, is that the file grows (and thus takes longer to send, defeating the purpose of on-line compression). This is true no matter what compression algorithm is used. Compression, ironically, involves some overhead.

Since the entire BBS world now uses off-line compression (via special utility programs) to achieve data reduction—and de facto high baud rates over telephone lines—the value of active data compression in a modem would seem to be undermined. Perhaps some modem manufacturers have incorporated automatic growth-detection and compression disablement schemes to deal with this problem.

Kas Thomas
Greenwich, CT

Whale Woes

In response to "Moby Dick 2.1" (Stop Bit, July), I would be happy to add my experience as an international reader of *Moby Dick*.

You may not be aware that *Moby Dick* was announced in translated versions at the same time as the U.S. version. Obviously, we had to wait another few months before we got translations of version 1.0.

Actually, we got version 1.0 in French at about the same time as you got 2.0. Unfortunately, most of the U.S. publishers with subsidiaries in Europe do not follow the same update policy in Europe and in the U.S.

What happened was that we received a letter stating that Moby Dick 2.0 was out (in English; the publishers just decided to drop the translation) and that we could get it if we sent a copy of the original invoice, the book, and a check (usually 15 percent of the newer version's price).

Many of us were pained; we had already made notes on the pages, and we would lose them. Many of us were not fluent enough in English. And many of us were disturbed to learn through BYTE that 2.1 was already shipping.

And some of us tried to get 2.1 direct from the U.S. Unfortunately, some publishers refuse to sell direct to Europe; you must go through the local dealer.

Finally, some of us had reported errors in 1.0 that we discovered were not corrected in 2.0 because of the local subsidiary.

Bernard Jousse
Barzun, France

We passed your letter on to Melville Press, which responded as follows:

Nous sommes tres heureux a announcer que Moby Dick es maintenant available in una versiona internationale. Esperamos que esta version gonna meeta all su expectationas. Si no, punta.

—Eds.

WE WANT TO HEAR FROM YOU. *Please double-space your letter on one side of the page and include your name and address. We can print listings and tables along with a letter if they are short and legible. Address correspondence to Letters Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.*

Because of space limitations, we reserve the right to edit letters. Generally, it takes four months from the time we receive a letter until we publish it.

Bigger vs. Better

"Is Bigger Better?" (July) was timely and well-taken. I have another consideration to add to those that Ezra Shapiro discussed: the problem of insufficient memory.

First I tried the 1988 edition of TurboTax, which I installed and brought up, only to find that 640K bytes was insufficient memory. To run the program, I first had to disable Norton Commander, which forced me to revert to the DOS

continued

command-line method of selecting programs. I also had to disable SideKick and SuperKey, which meant that I lost the screen blanking and the ability to make notes quickly.

Next I tried SuperCalc 5, which offered a few suggestions about freeing up memory; but those didn't make enough room, and I could load only the smallest spreadsheets unless I was willing to dispense with a 100K-byte buffer.

The two programs have all sorts of bells and whistles that are of no use to me. It would be great if they offered an optional stripped-down version that would leave enough memory for the workhorse utilities that I'm used to working with.

J. J. Hyde
Los Altos, CA

Feasible vs. Practical

We are writing in response to John William Mauchly Jr.'s letter (July) criticizing both our book, *The First Electronic Computer: The Atanasoff Story*, and G. Michael Vose's review of it (September 1988).

The most striking aspect of this letter from the son of the late John William Mauchly—who, with J. Presper Eckert, patented the ENIAC—is his failure to mention the federal court case on which our book is based, namely, the *Honeywell* v. *Sperry Rand* case that ended in invalidation of the ENIAC patent because of derivation from "one Dr. John Vincent Atanasoff." In supporting Judge Earl R. Larson's decision, we rely heavily on evidence and testimony from this trial.

The Honeywell side produced conclusive evidence that Atanasoff invented an "automatic electronic digital computer" between 1937 and 1942, that Mauchly learned all about it in 1941, and that Mauchly and Eckert used major features of it in the ENIAC and also in the EDVAC (the predecessor of the UNIVAC). The Sperry Rand side, for its part, could produce no evidence that Mauchly, prior to meeting Atanasoff, had progressed beyond a tiny neon flashing device in his claimed drive toward the ENIAC.

Mauchly himself gave some of the strongest testimony against his own early creative endeavors in electronic computing. He said, for example, that when he went to Iowa to see Atanasoff's computer, "I wasn't even thinking about inventing computing machines."

Thus, reviewer Vose should not be charged with too readily accepting "a book that attempts to rewrite history." The incorrect history was "rewritten" in an unappealed lawsuit, to which two corporations had devoted more than five years of legal effort and many millions of dollars. Vose not only cites that suit as the basis for our book, but also summarizes it.

Mauchly Jr.'s letter has two common arguments to which we want to reply—arguments disputing the status of Atanasoff's ABC as "the first electronic computer." It was not first, he claims, because it "never ran," and he cites the first airplane as surely "the one that flew." But the ABC did run: It solved small sets of linear equations correctly. Its computing devices, its memory, its controls, and its base-conversion system all worked fine; only an I/O flaw in its binary-card system caused a very infrequent error that made the solution of large sets unreliable.

The analogy to the first airplane is, indeed, appropriate. The Wright brothers

continued

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formulated the principles of flight, through experimentation, and then built an airplane that flew a short distance, proving flight feasible, although not yet practical. Atanasoff formulated the principles of electronic computation, through experimentation, and then built a computer that solved small sets of equations, proving electronic computation feasible, although not yet practical.

Moreover, Atanasoff's work led directly to the ENIAC and on to the first generation of stored-program computers.

Mauchly also claims that the ABC was only partly electronic, because of its rotating memory. But this memory embodied three computing principles employed universally today: electronic regeneration of memory elements, rotation as a means of memory access, and the use of capacitors as memory elements. Furthermore, Eckert and Mauchly thought enough of the ABC memory to include its form in their 1953 Regenerative Memory patent, an electronic computer memory patent that Judge Larson also found derived from Atanasoff.

Mauchly Jr.'s letter has another argument that we want to answer. He claims that we say his father got the very idea of electronic computation from Atanasoff, and then he cites a Mauchly letter written shortly before he met Atanasoff in which Mauchly declares his intention to build a key-operated "electronic computing machine to obtain sums of squares and cross-products." Actually, we take no such position; we even quote this letter.

What is worse is that Mauchly Jr. implies that this is all we say his father got from Atanasoff. In fact, we show that Mauchly got the concept of electronic switching, used throughout the ENIAC, from Atanasoff's computer, and the concepts of electronic memory regeneration and binary serial addition, used in the EDVAC (and the UNIVAC); moreover, that he and Eckert patented these concepts as their own.

John Mauchly Jr. concedes that our book replies to the arguments of his letter, but he asserts that our replies "only cloud the facts." We submit that he has conveniently sidestepped the real facts of this dispute—facts based on courtroom evidence and testimony.

His letter ultimately reaches a personal level, with completely groundless charges. Such tactics, however, cannot undo this sad, but true, tale of misappropriated ideas.

Alice Burks
Arthur Burks
Ann Arbor, MI

Power Protection

I have read Mark Waller's article on power protection ("PC Power," Parts 1 and 2, October and November 1988) and his text box ("What Is a UPS?") in the Product Focus entitled "Curing the Brownout Blues" (April). But I'm now having a problem. I can't find a power conditioner that is built like the one he discussed, and I'm planning to get the American Power Conversion 800rt and plug a conditioner into it. Can you give me the names and possibly the phone numbers of some of the manufacturers whose power conditioners meet with your approval?

I have one other question regarding something Waller said in the text box. On page 170 he seems to be saying that the ferroresonant design is a good one. But in the October 1988 article, he seems to

continued

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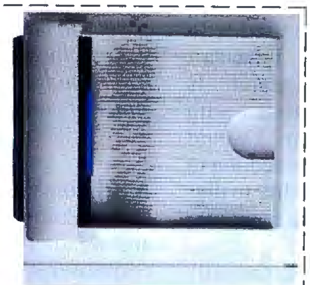

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Collates letters/envelopes	✓	yes**	no
Plotter emulation	✓	standard	optional
Resident fonts	✓	10	6
Font card size***	✓	credit card	"8-track" cassette
Standard weight	✓	33 lbs.	50 lbs.
Parts***	✓	400	1000
Dots per inch		300 x 300	300 x 300
Printer emulation	✓	IBM, HP compatible	HP compatible
Printer engine		IBM	Canon
List price	✓	$2,595	$2,695

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be saying that the ferroresonant design is a bad one because it regulates voltage, and the power supply in the computer doesn't need or want that. Can you explain and tell me if I should be looking for a ferroresonant design or avoiding it?

Bill Hogan
("bhogan" on BIX)
Wilmington, DE

That's a very good question. The seeming contradiction is one of expectation rather than application. When you think of an uninterruptible power supply, you expect it to do certain things over and above simply providing continuity of power. However, most UPSes or standby power systems cannot be counted on to be anything other than backup power sources.

Now, if the manufacturer has added a transformer, whether ferroresonant or low-impedance, this gives the device the features of a power conditioner. And this is the real point. Without a transformer of one kind or another, the neutral and ground are not bonded together—therefore, no common-mode protection is present. So a transformer is a must, whether it is included in the same cabinet as the UPS or purchased as a separate device.

So the choice is between a ferroresonant transformer and a low-impedance transformer like those found in most power-line conditioners. Ferroresonant transformers offer the benefit of regulating voltage, but PCs do not need voltage regulation for the reasons mentioned the article. Also, ferroresonant transformers are high-impedance devices, which means that they restrict the flow of current to the PC and cannot tolerate overload conditions. This is an undesirable characteristic, since the power supply in the PC wants to gobble lots of current every half cycle. Ferroresonant transformers are also inefficient, since the device is driven into saturation every half cycle. Therefore, they generate heat as well as audible noise. And they are three to five times heavier than the alternative. Ferroresonant transformers, however, are excellent normal-mode protectors, for the same reasons that created the weaknesses I have outlined above.

Low-impedance transformers do not restrict the flow of current and have high overload ratings. They offer no voltage regulation.

What it comes down to is this: A transformer is the best form of protection. Then the choice is between ferroresonant transformers, a good choice, and low-impedance power-line conditioners, the best choice.—Mark Waller

ASK BYTE

Start Talking

I have been considering computer applications that would involve files of digitally recorded sound effects and speech. A computer store salesman demonstrated such an application on a Macintosh II. I think that the product also included software and some kind of add-in card or sound-processing chip.

I have looked through a number of computer and electronics magazines for something similar that can be used with an AT-compatible computer. I haven't been very successful in my search. Is someone on your staff acquainted with such a product? At a minimum, I would like to have in/out jacks for connection to a stereo tape recorder. Any ability to digitally modify the sound in the computer would be a desirable option.

Regarding speech synthesis, the only consumer product I have seen is a dictionary/thesaurus from Franklin/Meriam-Webster that allows you to type in a word. It then displays definitions and speaks the word in a digitized voice. I would be interested in any other product that might be available that can be integrated into a computer.

Finally, I would appreciate any references or product names that would facilitate programming of animation on an AT-compatible computer. Most of the products I've read about deal only with Apple or Amiga computers.

David R. Brammer
Downers Grove, IL

You've stumbled into the two areas in which AT products are poorly represented. The application that you saw on the Macintosh was probably MacRecorder from Farallon Computing. Your average run-of-the-mill Mac includes hardware for playing back digitized sound. MacRecorder includes an external digitizing unit that plugs into the serial port and some spiffy editing software.

Alas, the MS-DOS world hasn't been graced with such cool toys. Digitized speech is done by simply sampling the analog signal with an A/D converter at twice the maximum frequency. You can record sounds with any reasonable ADC, providing it can sample at 6 kHz or better. You'd play back the sound through a DAC with similar capability. Software is another issue. I'm not aware of any software that promises general sound-editing capabilities. How well can you program?

Perhaps an easier way to get speech is with a commercial synthesizer. The Votalker-IB from Votrax (38455 Hills Tech Dr., Farmington Hills, MI 48331, (313) 553-0580) is a board that fits in the bus and has reasonable text-to-speech translation software. Street Electronics (1470 East Valley Rd., A-2, P.O. Box 50220, Montecito, CA 93150, (805) 565-1612), which is famous for Apple II speech products, sells a PC board called the Echo PC2. Either of these boards will produce acceptable speech output for under $100.

As for animation software, that's another area where commercial developers appear to have left the PC stranded.

Keep looking through the small ads in BYTE and other magazines. If you find either of these products, let us know.

—H. E.

A Silicon Weatherman

Do you know of a program on hurricanes and weather tracking? I have a Franklin computer that's compatible with the Apple IIe.

Rober J. Lever
Nokomis, FL

You can get computer-digestible weather data from a variety of sources. CompuServe (P.O. Box 20212, Columbus, OH 43220, (800) 848-8199) provides regularly updated maps that, with the proper software, you can display on-screen.

Other sources include Accu-Weather (619 West College Ave., State College, PA 16801, (814) 234-9601) and Weatherbank (2185 South 3600 West, Salt Lake City, UT 84119, (801) 973-3131).

Finally, if you want to put together your own weather station, the first eight issues of Circuit Cellar Ink *magazine (4 Park St., Vernon, CT 06066, (203) 875-2199) carried an involved computer weather-station project.*—R. G.

What Have I Caught?

I am using IBM AT and Dell 200 machines for work and development, and I'm encountering a computer virus. The symptoms are simple but very annoying—executable files that get contaminated grow by approximately 2K bytes after each load into RAM. Once a contaminated file is loaded into RAM, the RAM is contaminated, and any successive load of a clean file will contaminate that file.

The treatment I've chosen is to erase the contaminated file, cold-boot the PC, and load a clean file. For example, the executable file for dBASE III Plus 1.1 is about 133,632 bytes. After being loaded into contaminated memory, the file

continued

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Another is the step-by-step tutorial that actually takes you through every stage of programming by working you through a complete program.

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Microsoft QuickBASIC also comes with Easy Menus that let you develop programs with a minimum number of menu choices. Context-sensitive Help for immediate help with error messages and variables by simply punching a key, or clicking a mouse. And a built-in debugger that lets you see exactly what your program is doing, as it's doing it.

Best of all, Microsoft QuickBASIC is packed with enough power to handle whatever problems drove you to programming in the first place. Fact is, it translates your program into executable code at an incredible 150,000 lines per minute.

Microsoft QuickBASIC version 4.5. If programming is the only way out, this is the easiest way in.

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grows to about 135,200 bytes. (And this happens even with a read-only bit set.) I have no problem executing the file, however. Other programs completely hang the system, and I have to perform a cold boot.

Have you heard of this problem before? What is the best remedy?

Jonathan Cohen
Edison, NJ

We do have a remedy, but you may not like it. The only sure way to purge such a beast is to perform a low-level format on your hard disk drive and start from scratch. The virus has not only infected your executable files, it has tarnished your copy of DOS. If you now try to reinstall your applications using fresh floppy disks, your DOS will corrupt the new executables. It's a catch-22.

To kill off the virus, you should follow these steps:

1. *Copy all text and data files to backup floppy disks—you've got to abandon those executable and communications files.*
2. *Perform a low-level format on your hard disk drive.*
3. *Boot your system from a factory-original DOS disk and reinstall DOS.*
4. *Reinstall your executable files from the original-release disks.*
5. *Copy back your data files.*

This may seem like a drastic measure (especially if you don't have all your original-release disks), but you've got to destroy that copy of DOS. To prevent a recurrence, you should invest in a virus detector such as FLU-SHOT or SCAN34. Our January 1990 Product Focus will cover disk utilities; some of those packages include virus detectors.

We've heard of your problem before. Some similar strains include the Cascade virus (which expands files by approximately 1700 bytes) and the SumDOS virus (which expands files by approximately 1800 bytes). Don't you just love the folks who come up with these things? What a waste.—S. D.

My Computer Don't Rock

I am a third-year computer science student at AMA Computer College. I am also a part-time musician.

Ever since the introduction of MIDI software, I have been going through most of the shops in Manila trying to find a sequencing program. I have an IBM-compatible machine that I would like to use as a recorder/sequencer. Unfortunately,

continued

the shops here only have sequencing software for Apple's Macintosh.

Can you point me in the direction of a list of such MIDI software?

Alberto Vicente O. Santos
Manila, Philippines

There are a number of possibilities, so many that—although it might be impossible where you live—you should shop around and find the package that best meets your needs. Here's a partial list of products and manufacturers:

Texture and Prism
Magnetic Music
6 Twin Rocks Rd.
Brookfield, CT 06804
(203) 775-7832

Cakewalk
Twelve Tone Systems
P.O. Box 226
Watertown, MA 02272
(800) 234-1171

Master Tracks, Jr.
Passport Designs
625 Miramontest St.
Half Moon Bay, CA 94019
(415) 726-0286

Sequencer Plus
Voyetra
Dept. 470
333 Fifth Ave.
Pelham, NY 10803
(914) 738-4500

If you're interested in following trends in MIDI and the music industry, I suggest that you subscribe to Electronic Musician *magazine (P.O. Box 3747, Escondido, CA 92025, (800) 334-8152).*—R. G.

Fax Hunt

I have one telephone line into my apartment. I'd like to have three—one for voice, one for faxing, and one for my modem. Is there a way to combine them? I can imagine a modem that answers the phone and either receives the fax or data, or passes the call to my answering machine. Does anything like this exist?

Along the same lines, how can I receive a fax with a normal modem? I've seen dual fax/modem devices, but that seems like a waste. Can my 9600-bps modem receive fax data and then let some software translate the "fax-speak" into something I can use?

C. Conrad Cady
Oakland, CA

Short of investing in a new combination fax/modem, there is no simple solution to your problem. Fax machines are designed to answer the phone on the first ring. Modems can be programmed to answer the phone after a specified number of rings. The problem arises because fax machines and modems use incompatible methods to transmit data, and neither device is smart enough to recognize the other's signals (at least not yet). So, to answer your second question first, no, you can't program your 9600-bps modem to receive "fax-speak."

You can add an outboard automatic switching device that will respond to a specific command to divert an incoming call to either a fax machine or a modem. One model, the Bit Phaxswitch, answers a phone call with a digitized voice giving instructions to the caller. When the caller responds with the spoken word "fax," the

continued

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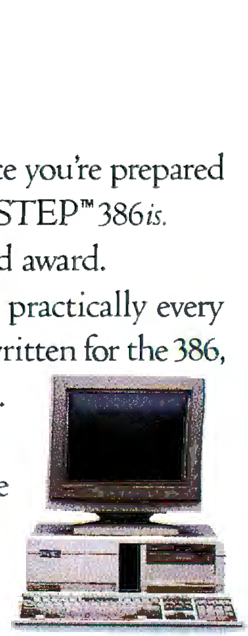

And it gives you all this 32-bit power for little more than a 16-bit price. (If you already own a STEP 286/12 or 286/16, by the way, you can easily upgrade your system to a STEP 386*is* just by plugging in our InSTEP™ daughterboard.)

Better yet, the STEP 386*is* comes with a host of other advantages.

Bit Phaxswitch diverts the call to the fax machine. The Bit Phaxswitch is available for $225 from Chaldar (P.O. Box 12566, El Paso, TX 79913, (800) 443-0791, fax (915) 772-4733).

Radio-Electronics *magazine ran an article showing how to build an automatic switcher (October 1989, page 33). The Fax-Mate requires the incoming caller to enter the pound sign (#) from a Touch-Tone telephone before it will divert the call to the fax machine.*—S. W.

I Need a Boost

I'd like to upgrade my Tandy 1200. Currently, my machine has an 8088 CPU, a 10-megabyte hard disk drive, and 256K bytes of RAM. My hobby is writing BASIC programs for genealogical and stamp-cataloging applications. All my programs are I/O-bound, even when compiled, and I'm looking for a way to improve execution speeds.

I'd also like to be able to run Peach-Tree Complete II, which requires 512K bytes of RAM and at least a 20-megabyte hard disk drive.

I read with interest the Short Take on the SOTA 286i accelerator (December 1988). Now I have literature from Sota describing its 386si accelerator and optional Memory/16i. From the literature, it appears that the 386si and the Memory/16i could provide faster execution and increase my system's main memory to 2 megabytes, all for about $1100. At this cost, I wouldn't hesitate to install a 40-megabyte hard disk drive for another $600. If all went well, I would be set for at least five years.

However, when I visited the local retailer that carries Sota products, I was advised that it would be a mistake to try to upgrade in this way. According to the salesperson, the Tandy 1200 has an 8-bit bus that would prevent an accelerator from producing any improvement in I/O speed. At the same time, the salesperson was trying to sell me a brand-new 80386 machine. At this point, I need a second opinion.

George A. Pohl
Sherrill, NY

If you installed the Sota 386si card, you would have an 80386SX running at 16 MHz. This would increase the computational speed of your Tandy 1200, but you would still be I/O-bound because of the limitations of the 4.77-MHz 8-bit bus.

I'd advise you to take that $1700 you wanted to invest in your old computer and purchase a newer AT compatible. You can get quite a reasonable machine with at least a 12-MHz 80286 CPU, 1 megabyte of RAM, and an EGA or VGA display for that amount. Check the ads in BYTE for a price comparison.

If you don't want to spend that much, at least increase the RAM in your Tandy 1200 to 640K bytes and obtain disk-caching and printer-buffering software. That will give you a noticeable improvement in I/O throughput.—S. W.

FIXES

- In "The Unix Shell" (September) on page 318, near the top of the second column, the example should read: `rm -r wp\*.*`. Omitting the backslash would cause all files in the current directory to be removed as well.
- In past months, the author's biography for David Fiedler (The Unix /bin) has been incorrect. Fiedler is the publisher of the journal *Root*, not the editor. Bruce Hunter is the editor. ■

CHAOS MANOR MAIL

Jerry Pournelle answers questions about his column and related computer topics

Stringing Up C

Dear Jerry,

Once again, you've shown your strong dislike for Unix and the C language. As I communicated to you before, I share your dislike of C's string-handling capabilities. Someone should improve that language by including in `<string.h>` the appropriate string functions to make C as easy as BASIC. An emulation of the MID$, INSTR, and string concatenating syntax is particularly needed. In the C language, there is no equivalent for all the things you can do with BASIC's MID$, while with other functions, such as LEFT$ and RIGHT$, you can write C subroutines easily enough. Maybe I am too stupid to write these, but I find string handling in C laborious; it can be done, but not elegantly.

A note about the Cray machine availability to the hoi polloi. With Intel's new chip, the 80860 (or N-10 or i860), we will soon see Cray-like desktop machines. There's little more need for the Cray and its availability.

Paul A. Elias
Fountain Hills, AZ

Well, the desktop Cray isn't quite *here yet.*—Jerry

Path-Name Lament

Dear Jerry,

I am writing to you in exasperation. I recently received Clipper, the dBASE compiler from Nantucket. I also have the SBT accounting system, which I keep organized in a number of different directories. I planned to use Clipper to recompile the SBT program whenever I make changes.

Much to my surprise, I discovered that Clipper does not support path names in its response files! There goes my file organization.

Now, we have had path names as part of the file specification since 1983, yet people are still writing programs that do not accept path names. Other examples are Make from Microsoft and Keymap from The Software Link. Frankly, I see very little excuse for this. If someone needs to access more than the maximum 20 files, then he or she can define a new file-handle alias table and set the address at offset 0034H to point to it and then set the word at 0032H to the size of the new table. The only thing to make sure of is that all files are closed and that 0032 and 0034 are reset to their initial values when the program terminates.

As for parsing a file specification, I created a complete file-specification parser. It required two days to complete. I wrote it in Microsoft Pascal, using an IBM editor. I now use it in all my programs that require parsing or simply checking the correctness of a file specification. Are these people telling me that I can do something with my feeble resources that these "professional" software companies cannot?

Ed Swaneck Jr.
Poland, OH

Yeah. I get to feeling that way, too.
—Jerry

APL Coding

Dear Jerry,

I read with some interest your "Language Sojourn" column (April). My company—a consulting firm—recently worked on a similar application. Unfortunately, instead of having the luxury of choosing an appropriate language, we were forced to do the job in STSC's APL*Plus.

We had originally planned on doing the job in C, which would have taken a trifle more code than in BASIC and brought us in a healthy fee commensurate with the effort involved. As you might imagine, this turned out to be a consultant's nightmare: Instead of billing for the effort of development of

continued

Jerry Pournelle holds a doctorate in psychology and is a science fiction writer who also earns a comfortable living writing about computers present and future. He can be reached c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458, or on BIX as "jerryp."

20,000 lines of code, we were able to stretch it out to only 2000 lines of code and bill on the basis of results—a fraction of what we had anticipated.

Jedediah West
New York, NY

For getting a problem solved fast, there's often no way to beat APL, and the STSC implementation is, APL enthusiasts tell me, very good.

I sure wouldn't want to maintain an APL program, though.—Jerry

Software Modeling

Dear Jerry,

Your comments on *The Limits to Growth* by Dennis and Donella Meadows (June) brought back memories of the early 1970s, when the work and the subject were "hot" topics. I had worked for almost two decades in the nuclear energy program at Argonne National Laboratory, and I was familiar with computer modeling and the "science fiction" that often came out of it.

I attended a meeting of the Chicago section of the American Institute of Chemical Engineers at which Jay Forrester was scheduled to talk, but Dennis Meadows filled in at the last minute. In the question-and-answer session afterward, I asked Meadows about how the data was used to validate the model, since he had described the historical demographic, economic, and industrial data used to fit the coefficients in the various equations assumed to be valid. In particular, I wanted to know whether they had ever run the model backward to see if it would predict the past—a sensitive test, and a logical one.

Meadows replied that they had tried it, but the results were unsatisfactory, and they had no clear explanation at that time, so it was not included. My response was that there was no model that I could imagine that would include the effects of innovation or of unexpected catastrophe, and that the work was an unreliable extrapolation of data beyond reliability based on the instincts and insights of the well-meaning investigators. I dimly recall uncharitably referring to it as "mathematical masturbation."

With the 20/20 hindsight that comes with additional years of learning, I now recognize that although the data covered periods involving the industrial revolution, urbanization of society and the problems of cities, the period of modern sanitation and medicine, and the migration of intellectuals due to the persecutions in Europe and Asia, these points were often included only peripherally and not in microscopic detail.

The recent spate of record high and low temperatures, of droughts and floods, and of increased ozone concentrations on the earth's surface and their decrease in the upper atmosphere indicate that, even with supercomputers, our models are better suited to predicting the past.

As an engineer, I am familiar with the successes of computer modeling of fluid flows. Yet they are still trying, retrospectively, to predict El Nino, the massive perturbation in the global weather cycle due to the coupling of the heat balance of the earth, winds, and oceanic upwelling. (A pedant would refer to this as thermal and hydrodynamic coupling between baroclinic and geostrophic flows.) We don't predict earthquakes; rather, we seek to minimize the consequences of earthquakes, volcanic eruptions, tornadoes and hurricanes, as well as other "short-term" natural disasters with major impact on the food chains, soil conservation, and the balances of weather and competing species.

I could go on, but you probably know as much as I do, or more. Where do we balance the responsibility to be complete and correct against calling attention to potential problems? The dilemma is an ancient one—free speech versus crying fire in a crowded theater, or crying wolf too often. In the nuclear safety business, we had some job security in thinking up unlikely mechanisms for accidents so we could study their potential consequences and how to prevent them. How is such "hazard mongering" different than the pronouncements of the Club of Rome?

In short, I enjoy your columns for their wide range and because they provoke thought, even if the problems don't always have a simple, or any, answer.

David Miller
Downers Grove, IL

When we were younger, "That's what the computer says" was a darned near unanswerable argument. Of course, computers can't do more than model what we already understand.—Jerry

Z-88 Problems

Dear Jerry,

I have been reading in BYTE about your adventures with a Sinclair Z-88. I have used one since October 1987, and I think my experiences might help you.

First, I think your machine is faulty. It shouldn't have lost your files, even if you didn't quite understand the file program-storage system. It also shouldn't have had the mysterious battery problem that you mentioned in the June issue.

My Z-88 showed similar problems. It would very occasionally lose all suspended activities when it was lying low and "switched off." Sometimes it would operate again only after a soft reset. On other occasions, it showed battery problems similar to the ones that you mentioned. Because these faults were infrequent and had no apparent common cause, I always tended to think that I had done something wrong and that the machine was really O.K.

After I had used the machine regularly for about 11 months, the problems became more frequent, culminating in one glorious day when the Z-88 decided that the RAM packs I was using weren't really there at all. It wouldn't access them in any way.

That's when I sent the machine back and got a new one. My new Z-88 is perfect—there have been no lost files, no power supply problems.

The moral of this story is: Don't keep blaming yourself; blame the machine, and change it for a new one.

I must be one of the few people around who use a Z-88 as their main computer. I have access to other microcomputers—IBM PCs and clones, Macintoshes, and so on—but I decided long ago that I would never buy myself a machine until I could find one that didn't take over because of its physical size. Even in an office or study, a desktop microcomputer is pretty intrusive. I suppose I was unduly affected by Alan Kay's Dynabook paper all those years ago.

Anyway, when the Z-88 turned up, I grabbed it, and it's marvelous. Admittedly, you have to plan its operation differently from that of conventional microcomputers, but that doesn't mean that its systems are wrong and that the rest are right. Cambridge Computers was obviously unlucky in the timing of the launch of the Z-88, which coincided with the rapid rise in memory-chip prices. But I can't help thinking that Clive Sinclair's abhorrence of disk drives will prove right in the long run. Here in England, there is a cheap cassette tape streamer on the market that avoids the need for expensive EPROMs.

J. G. Chadwick
Warrington, U.K.

Well, Sinclair sent me another Z-88, but getting it seems to have cured all the problems of the original one!

I don't think I'd care to use the Z-88 as my only computer, but I do like its light weight, and I carry it most places I go.

—Jerry ■

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Apollo Underprices 68030-Based Unix System

The Apollo Series 2500 is a workstation—with all the bells and whistles of a LAN node—at a personal computer price. It includes a 20-MHz Motorola 68030, a 68882 floating-point coprocessor, 4 megabytes of RAM, and a 15-inch paper-white display with a maximum resolution of 1024 by 780 pixels.

There's no need for a hard disk drive; the system has networking support that includes built-in Ethernet, IBM Token Ring, and Apollo Token Ring support, Apollo says. But if you'd like a local drive, you can buy an optional 100- or 200-megabyte SCSI hard disk drive.

All the features of the 2500 are built onto a single motherboard that's approximately the size of a full-size IBM AT board. The only expansion slots are for the hard disk drive controller and for memory. The 2500 has room for 16 1-megabyte single in-line memory modules. When 4-megabyte SIMMS become available, users will be able to pack the machine with 64 megabytes, Apollo says.

The 2500 comes with Unix System V release 3. Apollo says that the system will run any of the 2500-plus Unix applications that run on other Apollo systems.

Price: $3990; with 100-megabyte SCSI hard disk drive, $5490; with 200-megabyte SCSI drive, $8495; 19-inch monitor, $1500.

Contact: Hewlett-Packard Co., Apollo Division, 330 Billerica Rd, Chelmsford, MA 01824, (508) 256-6600.

Inquiry 1127.

Apollo built its Series 2500 with LAN support and Unix workstation performance.

Put an 80386SX in Your Lap

The LapPRO-386SX from Dauphin Technology is an 8-/16-MHz 80386SX-based laptop system with no wait states. It comes with 2 megabytes of RAM, which you can expand to 4 megabytes.

Also included is a 40-megabyte 28-ms hard disk drive and a 1.44-megabyte 3½-inch floppy disk drive. You can also have the factory install a 5¼-inch floppy disk drive. A 10-inch 640- by 400-pixel LCD EGA/CGA monitor is standard, as is a 75-key keyboard with a numeric keypad.

The system's internal power supply automatically adjusts to changes in voltage, according to the manufacturer. It operates from a 110- or 220-volt power source, and also from a 12-V cigarette lighter. There's a removable and rechargeable battery pack.

The LapPRO-386SX measures 3 inches high by 12⅗ inches wide by 16 inches deep, and it weighs 16½ pounds with the battery pack.

Price: $4995; expansion chassis, $295; 80387SX-16 math coprocessor, $550; 4-megabyte upgrade, $735; 2400-bps internal modem, $189; 360K-byte floppy disk drive, $259.

Contact: Dauphin Technology, Inc., 1125 East St. Charles Rd., Lombard, IL 60148, (312) 627-4004.

Inquiry 1128.

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Wang Reinforces Its PC Presence

Wang Laboratories has reinforced its formerly sparse line of IBM PC compatibles with four new systems. The quartet of Wang-designed-and-built clones includes 16- and 20-MHz 80286-based systems and two 80386SX-based systems: a 16-MHz AT clone and the company's first Micro Channel PS/2 clone.

The two 80286-based systems (dubbed the PC 250/16 and PC 280/20) and the 80386SX-based AT compatible (the PC 350/16S) include 1 megabyte of RAM and a single 3½-inch floppy disk drive. Wang touts its 16-MHz 80386SX-based MC 350/16S as compatible with IBM's PS/2 Model 55 SX but claims it has more on-board memory capacity and expansion options. The system includes five Micro Channel slots, 2 megabytes of RAM, a single 3½-inch floppy disk drive, and an on-board 16-bit VGA.

All four systems let you put up to 8 megabytes on the motherboard. Monitors are optional.

Price: PC 250/16, $2095; PC 280/20, $2995; PC 350/16S, $2695; MC 350/16S, $2995.

Contact: Wang Laboratories, Inc., One Industrial Ave., Lowell, MA 01851, (508) 459-5000.

Inquiry 1129.

continued

Really Seeing What You Get

While many applications trumpet their WYSIWYG abilities, the fact remains that what you see on the screen is only an approximation of the final printed output.

But MegaScan Technology's Document Display System (DDS) changes all that. With a display resolution of 4096 by 3300 pixels on a 19-inch paper-white noninterlaced diagonal screen, it actually shows 300 dpi on the screen, for nine times the display density of a VGA monitor.

The DDS has an active screen area of 13⅗ by 11 inches, letting you see full-page documents at the same size, density, and image quality—dot for dot—as laser-printed output. MegaScan claims that while fonts that are smaller than 8 points are usually illegible even on high-resolution monitors, DDS users can comfortably read fonts that are as small as 4 points.

The DDS card uses a 2-megabyte frame buffer, holding document images that are up to 12 million pixels, along with menus, display primitives, and data structures. And the system's dual-ported video RAM has a 1.5-gigabit-per-second data transfer rate to the monitor controller via a short optical-fiber cable. The monitor itself uses a 72-Hz refresh rate.

The DDS is available for the IBM AT and compatibles, as well as VMEbus systems such as Sun workstations. Drivers for popular graphical user interfaces, including Windows, are available now, with a Presentation Manager driver expected to be available by the end of the year.

Price: $11,000.
Contact: MegaScan Technology, Inc., 42 South St., Hopkinton, MA 01748, (508) 435-2600.
Inquiry 1136.

Smart, Cordless Mouse Distinguishes Between Apples, Amigas, and Ataris

Practical Solutions' new Cordless Mouse for Apple, Amiga, and Atari systems includes an 8-bit 12-MHz CMOS microprocessor for plug-and-play compatibility, the company says.

In conjunction with an infrared receiver and a set of adapters for the receiver, the Cordless Mouse works with Macintosh Plus, SE, and II models; all Amiga models; and both the Atari ST and Mega models, Practical Solutions says.

Resolution is 200 dpi, and tracking speed is rated at up to 600 mm per second. Like most other rodents, the Cordless Mouse also has ballistic control, so the faster you move the mouse, the faster the cursor jumps across your screen.

For power, each Cordless Mouse requires two AAA batteries. A sleep mode works after the mouse is idle for more than 2 minutes, and an automatic shutoff function powers down the mouse after it sits idle for more than 10 minutes.

Price: $149.95.
Contact: Practical Solutions, 1135 North Jones Blvd., Tucson, AZ 85716, (602) 322-6100.
Inquiry 1137.

Light Pens Meet PCs and CAD Terminals

The DT200 series of 1024- by 1024-pixel light pens is available for CGA, EGA, Super EGA, and VGA monitors, as well as for customized plug compatibility with several terminals.

Mac compatibility is next, the company promises, with a Mac product planned for mid-1990. Supported terminals—for CAD, process control, and menu selection—include Beehive, Harris, Telex, C. Itoh, Memorex, and Wyse.

Price: $135 to $210.
Contact: Design Technology, 1050-R Pioneer Way, El Cajon, CA 92020, (619) 440-7666.
Inquiry 1139.

Give Your PS/2 a Nine-Track Tape Memory System

Interface Data's XT/AT-compatible nine-track tape system is now available on PS/2 platforms. The new system consists of a Micro Channel architecture–based add-in card with cabling to your choice of breadbox-size or two-breadbox-size peripherals. Included on your MCA card is a 5-MHz Z80-based processor, which facilitates data transfer to a maximum rate of 250K bytes per second. Data transfer mode is direct memory access, interrupt controlled. RAM is 64K bytes.

Series 3/98 will read tapes on 7-inch reels at data densities of 1600 and 3200 bits per inch (for data backup). The larger Series 3/99 systems read tapes on 10½-inch reels. Each Series 3/99 reads tape densities of 1600 and 3200 bpi, as well as the more traditional 800-bpi densities. A high-performance Series 3/99 GCR (group code recording) system can handle tapes with 6250-bpi densities.

Price: Series 3/98, $4995; Series 3/99, $5499; Series 3/99 GCR, $10,995.
Contact: Interface Data, Inc., 800 West Cummings Park, Suite 6900, Woburn, MA 01801, (617) 938-6333.
Inquiry 1138.

Two Printers in One

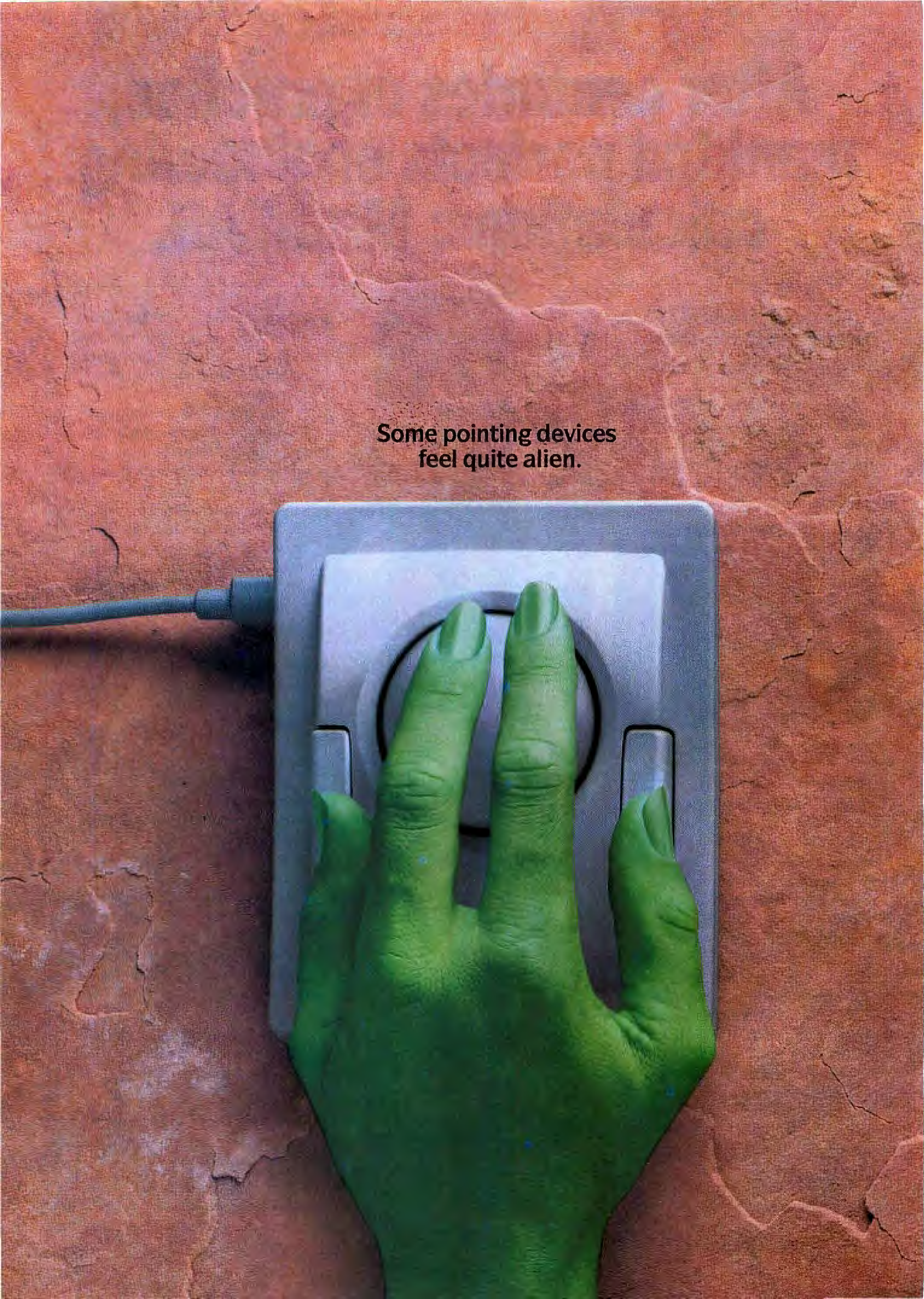
If your printing needs include both PostScript and Hewlett-Packard page-control-language (PCL) capabilities, Personal Computer Products' dual-standard LaserImage 1100-PS will eliminate the big bucks and space problems of buying two printers. The 1100-PS includes both an Adobe PostScript interpreter and HP LaserJet Series II emulation. You can switch between the two with a front-panel switch.

The printer's PostScript interpreter has 35 typefaces from 11 font families, and, according to the company, it supports the entire Adobe library of downloadable fonts. On the Hewlett-Packard side, the 1100-PS includes 24 standard fonts, as well as support for all PCL-compatible downloadable fonts.

The 1100-PS comes with RS-232C, RS-422, and parallel ports. It's rated at 6 pages per minute at 300-dpi resolution. Two megabytes of RAM is standard, and you can expand it to a maximum of 4 megabytes. The standard paper tray holds 150 sheets, and the auxiliary tray holds 250 sheets. The printer is available alone or bundled with the ImagePress desktop publishing software.

Price: $4995; with ImagePress, $5295.
Contact: Personal Computer Products, Inc., 11590 West Bernardo Court, Suite 100, San Diego, CA 92127, (619) 485-8411.
Inquiry 1135.

continued

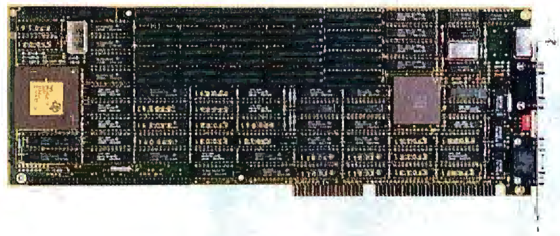

Some pointing devices
feel quite alien.

Cutting-Edge Graphics for ATs

If VGA resolution, speed, and color choice aren't sufficient for your needs, Hewlett-Packard has a pair of IBM PC graphics boards that go beyond VGA by using Texas Instruments' dedicated graphics processor chips.

The HP Intelligent Graphics Controller 10 (IGC-10) uses a TI TMS34010 graphics processor. It gives you a 16- or 256-color display out of a palette of 256,000 and can display applications in 640 by 480, 800 by 600, and 1024 by 768 pixels. Hewlett-Packard says that in performance, the IGC-10 betters a standard VGA card by five times.

On the high end, the company claims that the Intelligent Graphics Controller 20 (IGC-20) is the first shipping PC graphics card based on the Texas Instruments TMS34020 graphics processor. It has 15 times the performance of a conventional VGA card, Hewlett-Packard says. With a capable monitor, the IGC-20 can give you 1024- by 768-pixel or 1280- by 1024-pixel resolution, and it displays 256 colors out of 16.7 million.



Hewlett-Packard says that its IGC-20 is a TMS34020-based board that offers 15 times the performance of a conventional VGA card.

Both the IGC-10 and IGC-20 work with all IBM ATs and compatibles, as well as the new generation of EISA-bus systems. They're compatible with all software that works with the TIGA (Texas Instruments Graphics Architecture) 340 and the new Direct Graphics Interface Standard. DGIS-compatible software includes such common graphical user interfaces and applications as Microsoft Windows and GEM. Both boards also have a "VGA pass-through" feature that lets you use them in your system in conjunction with a standard VGA board.

The boards each come with 512K bytes of RAM. But if you need even better performance, you can upgrade them. The IGC-10 takes up to 1 megabyte of video RAM and up to 3.5 megabytes of RAM; the IGC-20 will handle 2 megabytes of VRAM and 3.5 megabytes of RAM.

Price: Intelligent Graphics Controller 10, $995; Intelligent Graphics Controller 20, $2495; 512K-byte VRAM upgrade, $400; 512K-byte RAM upgrade, $330.

Contact: Hewlett-Packard Co., 3404 East Harmony Rd., Fort Collins, CO 80525, (303) 229-3800.

Inquiry 1141.

Add 80386SX Power to Your Wimpy 80286

While upgrading your 80286-based AT to the greater power of a 32-bit 80386SX processor has been possible for quite a while, you've been limited to add-in cards that are constrained by the speed of the bus. Cumulus says that its 386SX Card gets by this limitation through the simple process of plugging directly into your motherboard's processor socket.

The 16-MHz 386SX card replaces 80286 processors with clock speeds of up to 16 MHz. Cumulus says that if you have an AT or compatible that runs at 8 MHz, you can expect a performance gain of 10 percent to 15 percent. The card, which measures 2½ by 2½ inches, also has a socket for an optional 80387SX math coprocessor. The company claims that this gives you four times the performance of an 80286/80287 combination.

The company says that once you've installed the 386SX Card, you'll be able to run all 80386-specific software, such as Windows/386 and DESQview/386. Also included is software that lets you run expanded memory (EMS 4.0) applications in your system's extended memory.

The 386SX Card is compatible with PGA (pin grid array) and PLCC (plastic leaded chip carrier) socket types. You can install it in most IBM ATs, PS/2s, and compatibles, including the PS/2 Models 30 286, 50, 50 Z, and 60, and the Compaq Deskpro 286.

Price: $595.

Contact: Cumulus Corp., 23500 Mercantile Rd., Cleveland, OH 44122, (216) 464-2211.

Inquiry 1140.

Link Your Micro Channel to a Laser Printer

The JLaser6-MC uses a high-speed direct video interface from your computer to your laser printer's print engine. According to Tall Tree Systems, this gives you print speeds that are two to six times faster than what you get using a standard parallel printer interface. It works with the Hewlett-Packard LaserJet Series II and all Canon SX print-engine-based printers.

The interface also gives you the ability to print true halftone images with up to 256 levels of gray at 70 lines per inch, and up to 128 levels of gray at 106 lines per inch. The company says that this is done by modulating the laser beam to a much higher resolution than normal.

For printing bit-mapped images, the JLaser6-MC needs 2 megabytes of expanded memory. If your system doesn't have EMS-compatible memory, you can add an optional 2-megabyte daughterboard to the JLaser6-MC that also gives you a SCSI port.

The JLaser6-MC package comes with a Micro Channel board, a video interface board for your laser printer, a connecting cable, and a Bitstream Fontware disk. It also comes with drivers for Microsoft Windows, GEM, and Ventura Publisher, plus JBanner (an image and text utility) and JPlot (a Hewlett-Packard Graphics Language emulator).

Price: $599; with 2 megabytes, $899.

Contact: Tall Tree Systems, P.O. Box 50690, 2585 East Bayshore Rd., Palo Alto, CA 94303, (415) 493-1980.

Inquiry 1143.

continued

If You Want To Talk Fast DBMS Call 1-800-db-RAIMA™ And Start Screaming

You'll be screaming, all right. db_VISTA III from Raima Corporation combines the flexibility of a relational DBMS and the lightning speed of the network database model.

C db_VISTA III is written for C Programmers. Source code available. The interactive database utilities and outstanding documentation make db_VISTA III easy to learn. All applications are portable to VMS, UNIX, OS/2, MS-DOS, even Macintosh. No royalties.

db_VISTA III is *Fast*. Using benchmarks originated at PC Tech Journal Laboratories, db_VISTA III measured *3 to 12 times faster than the average relational database!* Call us and we'll send you the results.

Relational and Network Model Technology for Programming Flexibility. Retrieve a record fast using the relational keyed access method and all related records can be immediately available using the network model. You decide how to combine these for best application performance.

db_VISTA III Database Management System

Features	Yes	No
db_VISTA 3.1 High Performance DBMS:		
Single and Multi-User available	✓	
Relational B-tree Indexing	✓	
Network Database Model	✓	
Multiple database access	✓	
Referential integrity	✓	
Automatic recovery	✓	
Record & File locking	✓	
RAM resident		✓
db_QUERY 2.1 SQL-based Query:		
Relational Query & Report Writer	✓	
db_REVISE 1.0 Database Restructure Program:		
Total database redesign/restructuring	✓	
Operating Systems*: VMS, ULTRIX, UNIX	✓	
BSD 4.2, SunOS, XENIX, MS-DOS,	✓	
Macintosh and MS Windows, OS/2 compatible	✓	
C Compilers*: Most compilers supported	✓	
C++ compatible	✓	
LANs*: 3COM, Novell, Banyan, AppleShare	✓	
WKS Library:		
Read & Write WKS, WK1 & DBF files	✓	
SOURCE CODE AVAILABLE:	✓	
ROYALTIES: (Absolutely not!)		✓✓

*Other environments are supported; call for complete list.

SQL Support with SQL-based db_QUERY, db_VISTA III's relational query and report writer.

db_VISTA Puts You in Some Fast Company. Thousands of C programmers in over 50 countries worldwide use db_VISTA III, including APPLE, ARCO, AT&T, EDS, Federal Express, Hewlett-Packard, IBM, NASA...

Don't wait. Call Raima for more information about how you can build applications that are *screaming-fast!*

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Argentina: 54 1 313 5371 Chile: 56 2 696-4308 Uruguay: 598 2 95 29 59 Central America: (506) 28 07 64 © Copyright 1989 Raima Corporation.

Inexpensive Word Processor in a 3-pound Package

The WP-2 is an inexpensive laptop computer built for word processing. It features a 5.5-MHz Z80 chip, a 62-key QWERTY keyboard, and an 80-column by 8-row LCD screen. Standard memory is 32K bytes, 22K bytes of which is available for documents.

Besides the word processing program, Tandy added a 100,000-word spelling checker, a 200,000-word thesaurus, and communications software that supports ASCII and XMODEM.

Using the two function keys in combination with number keys, you can cut, copy and paste, search and replace, center and justify text, output to a printer, or initiate telecommunications. The telecommunications software runs through the WP-2's serial port, and there's a parallel port for printing.

The 8½- by 11¾- by 1-inch WP-2 is powered by four AA batteries, which Tandy rates at 12 hours. A lithium battery backs up the RAM and has an estimated life of more than five years.

Options include an AC adapter, 32K bytes of internal RAM (which must be dealer-installed), and an IC card that plugs into a side slot on the computer with an additional 32K bytes of RAM.

Price: $349.95; internal 32K bytes of RAM, $49.95; IC card, $119.95; AC adapter, $6.95.

Contact: Tandy Corp., 1800 One Tandy Center, Fort Worth, TX 76102, (817) 390-2129.

Inquiry 1147.

Tandy's WP-2 is a dedicated word processor with a built-in 200,000-word thesaurus and communications software.

Virtual Software for a Real Oscilloscope

Developed by National Instruments, CAT200 Virtual Instrument Software is the first shipping example of the company's DOS-based virtual-instrument technology. It's used to control Tektronix's 222 Digital Handheld Oscilloscope through a standard RS-232C serial link.

CAT200 re-creates on your computer screen the entire front panel of the oscilloscope, allowing you to acquire, analyze, reduce, and store data using any IBM PC, PS/2, or compatible (including laptops). Tektronix says that the package is designed for both experienced and novice users.

Using a mouse, you can point and click to activate any of the 222's controls. You can also store commonly used setups for nearly hands-free use in the field. The package can display up to six different waveforms, which you can store for later analysis or compare with incoming signals.

Tektronix says that a unique feature of the CAT200 package is its built-in support for Hayes-compatible modems. Using the telephone lines, you can link a PC running the package to a remote 222 scope, turning the telephone network into ultralong probes. You can then control the scope from your PC, just as if it were next to you. You can also upload and download captured waveforms between locations.

The software requires 640K bytes of RAM, an EGA or VGA graphics card, a hard disk drive, and a serial port.

Price: CAT200, $395; 222 Digital Handheld Oscilloscope, $2450.

Contact: Tektronix, Inc., P.O. Box 500, Beaverton, OR 97077, (503) 627-7111.

Inquiry 1149.

Spectrum Analyzer Includes an XT

Rapid Systems' R375 is a 10-MHz IBM PC XT-based fast Fourier transform spectrum analyzer designed for engineering testing, including vibration, impact, ultrasound, modal, and mechanical analyses.

It analyzes two channels at once, with frequencies of up to 10 MHz and in the time domain to 2 MHz at 10 samples per cycle. Using a built-in digital signal processor, it can simultaneously display frequency spectra and associated time waveforms. Then you can automatically save the data to the 20-megabyte hard disk drive or to a floppy disk. The display is EGA-compatible, there's a mouse interface, memory is 640K bytes, and there is one serial and one parallel port.

Other features include linear or log scales, windowing, 65-dB dynamic range, programmable gain from 0.256 millivolt to 512 volts, switchable impedance from 50 ohms or 1 megohm, and 128K bytes of waveform memory.

Price: $6995.

Contact: Rapid Systems, Inc., 433 North 34th St., Seattle, WA 98103, (206) 547-8311.

Inquiry 1148.

Battery Power for Days on End

You can drive any electrical device that requires 12 volts of power, such as a portable computer, with the Bat/Pak 30-ampere-hour battery pack, according to Horizon Entertainment.

The pack comes with a meter, switch, fuse, and two output receptacles (XLR and cigarette lighter). The battery is a sealed lead-acid deep cycle type mounted in a case covered with black fiberglass and insulated with one-half inch of foam. The unit weighs about 25 pounds and measures 6¾ inches wide by 9½ inches deep by 9½ inches high.

Price: $295; XLR charger, $39.95.

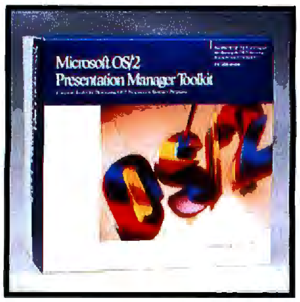
Contact: Horizon Entertainment, Inc., P.O. Box 300146, Houston, TX 77230, (713) 747-6433.

Inquiry 1146.

continued

Programmer's Paradise *(800) 445-7899*

***Microsoft**, the industry trend setter at providing language tools for the software developer has done it again, with three new products to lead the way into the 90's. And Programmer's Paradise, the world's leading source of development software is ready to ship them to you. Call us today to order these and other outstanding Microsoft software products.*



Microsoft OS/2 Presentation Manager Toolkit

The Microsoft OS/2 Presentation Manager Toolkit provides a complete set of visually-oriented software tools and documentation to help you develop the next generation of graphical applications for the OS/2 Presentation Manager. Presentation Manager provides a consistent, graphical user interface that makes applications easy to learn and use. The Toolkit includes the software to create and customize drop-down menus, dialog boxes, icons, and fonts that make this intuitive environment possible. Also included is a complete set of reference documentation; QuickHelp, the on-line, context sensitive reference; HelpMake to add to the QuickHelp database; over 3 MB of sample code; and 2 free hours of on-line support.

Microsoft QuickPASCAL

A powerful new implementation of Pascal that provides superior productivity and performance to current Pascal programmers, and also opens the door to object-oriented programming.

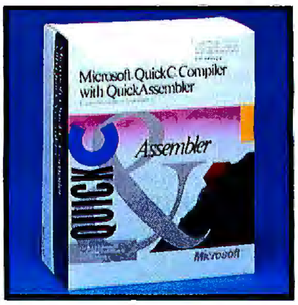
The QuickPASCAL compiler and linker are the fastest available for Pascal on a PC, assuring superior performance.

And QuickPASCAL integrates a compiler, editor and debugger into one highly productive, intuitive environment.

Object-oriented programming is expected to be the major programming development of the 1990s. Microsoft's implementation of object-oriented constructs in QuickPASCAL will provide you with an easy, smooth transition into object-oriented techniques.

Microsoft QuickC Compiler with QuickAssembler

Microsoft QuickC Compiler with QuickAssembler is the first product to fully integrate C and assembly language into one seamless environment, giving you maximum power and ease of use. Write and edit source code in C; accelerate speed-critical routines or gain low-level access to your hardware with assembly language; compile, assemble, run, and debug–all within the same integrated software development system. Comprehensive reference guides and innovative on-line learning tools make the two languages and the unique integrated environment easy to master. Two popular languages, one smooth environment–the power of C and the speed of assembler, together at last! Amazing!



THE MICROSOFT PRODUCT LINE

	LIST	OURS
MS BASIC/6.0	295	**199**
MS C	450	**299**
MS COBOL	900	**599**
MS Excel	495	**279**
MS Excel (MAC)	395	**279**
MS FORTRAN	450	**299**
MS Learning DOS	50	**40**
MS Mach 20	495	**329**
MS Macro Assembler	150	**99**
MS Mouse Bus or Serial		
w/ Paintbrush & Mouse Menus	150	**99**
w/ EasyCAD	175	**119**
w/ Paintbrush & Windows	200	**139**
MS OS/2 Presentation Manager Softset	150	**105**
MS OS/2 Presentation Manager Toolkit	500	**329**
MS Pageview	50	**40**
MS Pascal	300	**199**
MS PowerPoint (MAC)	395	**279**
MS QuickBASIC	99	**69**
MS QuickBASIC (MAC)	99	**69**
MS QuickC	99	**69**
MS QuickC with QuickAssembler	199	**135**
MS QuickPASCAL	99	**69**
MS Sort	195	**130**
MS Windows/286	99	**69**
MS Windows/386	195	**130**
MS Windows Software Development Kit	500	**319**
MS Word	450	**279**
MS Word (MAC)	395	**279**
MS Works	149	**99**

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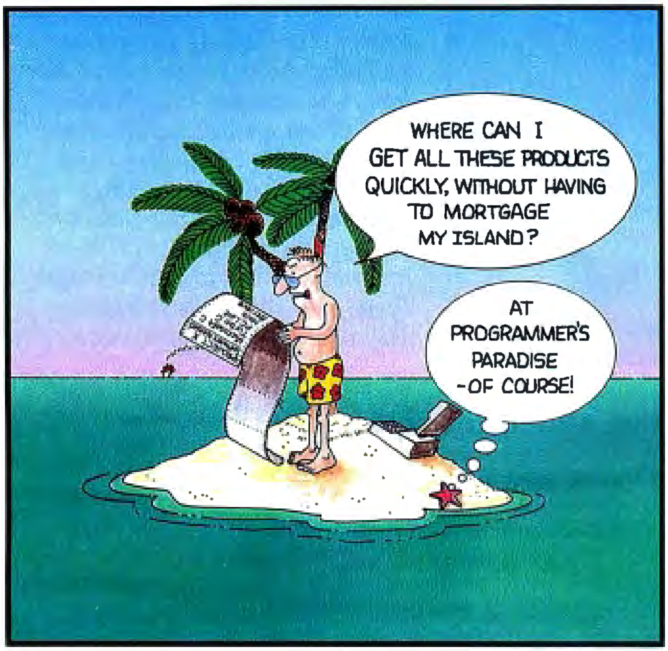

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386 PRODUCTS

	LIST	OURS
386 ASM/LINK	495	435
386/VMM	295	239
386MAX	75	66
386MAX PROFESSIONAL	129	109
C Network Compiler/386	995	799
DESQview 386	190	169
Lahey F77L-EM/32	895	795
Microsoft Windows/386	195	135
NDP FORTRAN-386	595	549
Paradox/386	895	625
VM/386	245	199
VM/386 Multi-User	895	759
VM/386 NetPak	150	119
VM/386 & NetPak Bundle	399	269

ADA LANGUAGE

	LIST	OURS
IntegrAda	795	749
Janus/Ada Compiler	300	269
Janus/Ada Options Kit	500	449
Meridian:		
AdaGraduate	495	445
AdaStudent	50	45
AdaTutor	150	135
AdaVantage Developer's Kit	1095	985
AdaVantage PC Prof. Dev. Kit	1780	1599

ASSEMBLY LANGUAGE

	LIST	OURS
Advantage Disassembler	295	279
MS Macro Assembler	150	99
OPTASM	125	109
Sourcer w/ BIOS source	140	125
Turbo Assembler/Debugger	150	105
Visible Computer: 80286	100	89

BASIC COMPILERS

	LIST	OURS
MS BASIC/6.0	295	199
QuickBASIC	99	69
True BASIC	100	69
Turbo Basic	100	69

BASIC LIBS/UTILITIES

	LIST	OURS
db/LIB	139	121
Designer QuickWindows	59	55
DiaLogic	79	70
Finally!	99	89
GraphPak	79	70
GraphPak Professional	149	125
LaserPak	79	70
ProBas	135	125
ProBas HyperHelp Toolkit	99	94
ProBas Telecomm. Toolkit	75	70
ProBas Toolkit	99	94
ProMath	99	94
ProScreen	99	89
QBase Report	79	70
QBase and Quickscreen	149	125
QuickComm	139	125
QuickHelp	59	55
QuickMenu	59	55
QuickPak	79	70
QuickPak Professional	149	125
QuickPak Scientific	79	70
QuickScreen	79	70
QuickWindows Advanced	139	125
QuickWindows Advanced Corp.	500	445

C COMPILERS

	LIST	OURS
C Network Compiler	695	525
Lattice C 6.0	250	199
Microsoft C	450	299
MS QuickC	99	69
MS QuickC w/ QuickAssembler	199	135
Turbo C	150	99
Turbo C Professional	250	169
WATCOM C 7.0	395	319
Zortech C	90	79

C++

	LIST	OURS
Guidelines C++	295	269
Zortech C++	200	165
Developer's Edition	450	385
Zortech C++ Tools	150	129

C-COMMUNICATIONS

	LIST	OURS
Breakout II	125	99
C Asynch Manager 3.0	189	139
Essential Communications	249	199
Greenleaf Comm. Library	299	209
Greenleaf ViewComm	559	475
Lattice Communication Library	250	209
SilverComm C Async Library	249	209

C-FILE MANAGEMENT

	LIST	OURS
Btrieve	245	185
Btrieve for DOS 3.1 Networks	595	449
CBTREE	159	135
C Index +	99	89
C-ISAM	225	209
Codebase IV	295	219
CQL w/ PASS	395	349
c-tree	395	315
dBC III	250	219
dBC III Plus	500	439
db_FILE Bundle	295	249
Essential B-Tree	99	89

C-GENERAL LIBRARIES

	LIST	OURS
C TOOLS PLUS/6.0	149	109
C Utility Library	199	139
Greenleaf Functions	229	165
Greenleaf SuperFunctions	299	209
Turbo C TOOLS/2.0	149	109

C SCREENS

	LIST	OURS
C-Worthy w/ forms and source	495	CALL
Facelt	99	89
Greenleaf DataWindows	395	279
JAM	595	529
Panel Plus	495	395
Vermont Views	395	CALL
Vitamin C	225	165
VC Screen	149	115

C-UTILITIES/OTHER

	LIST	OURS
Clear +	200	169
C-Terp	300	219
Heap Expander	80	70
Norton Guides for C	100	65
PC-lint	139	105
PCYACC Professional	395	359
TimeSlicer	295	279
w/source	1000	899

COBOL LANGUAGE

	LIST	OURS
Micro Focus:		
COBOL/2 w/ Toolset	1800	1499
COBOL/2 Toolset	900	749
Personal COBOL	149	129
MS COBOL	900	629
Realia COBOL	995	849
w/ RealMENU	1145	979
SCREENIO	400	375

CODE GENERATORS

	LIST	OURS
C Source	395	299
Logic Gem	198	179
Matrix Layout 3.0	200	169
PRO-C	399	339

DATABASE DEVELOPMENT

	LIST	OURS
Clarion 2.0	695	499
Clear +	200	169
Clipper 5.0	695	439
dBASE IV	795	489
dGE	195	179
Dr. Switch	60	55
Dr. Switch DeveloperPak	99	89
FoxBASE+	395	249
Magic PC	299	249
Paradox 3.0	725	509
R&R Report Writer	150	129
w/ Clipper/ FoxBASE module	200	159
R&R Code Generator	150	129
Say What?!	50	45
SilverComm Library 2.0	189	165
C Interface	99	89
SilverPak	295	249
Tom Rettig's Library	100	80

EDITORS

	LIST	OURS
BRIEF 3.0	199	CALL
Edix	195	165
Epsilon	195	159
KEDIT 4.0	150	125
MKS Vi	149	129
Norton Editor	75	59
SLICK Editor	195	175
SPF/PC	245	199
VEDIT PLUS	185	115

FLOWCHARTING

	LIST	OURS
EasyFlow, Interactive	150	115
Flow Charting II+	229	179
RFFlow	79	70

FORTRAN LANGUAGE

	LIST	OURS
Grafmatic	135	119
Lahey F77L	595	529
Lahey Personal FORTRAN 77	95	89
MS FORTRAN	450	299
Plotmatic	135	119
Printmatic	135	119
RM/FORTRAN	595	499

GRAPHICS LIBRARIES

	LIST	OURS
Baby Driver	250	225
Essential Graphics	299	239
Font-Tools	150	135
Graf-Text	89	79
GraphiC 5.0	395	322
Graphics-MENU	195	175
GSS Graphics Devel. Toolkit	595	509
HALO	395	279
HALO Window Toolkit	595	419
Icon-Tools/Plus	150	135
MetaWindow	250	209
MetaWindow Plus	325	269
Menuet	250	225
PCX Effects	99	89
PCX Programmer's Toolkit	195	175
PCX Text	149	135
XVT	595	509

LINKERS/LIBRARIANS

	LIST	OURS
Plink86plus	495	419
PolyLibrarian II	149	135
.RTLink	195	185

MODULA-2

	LIST	OURS
LOGITECH Modula-2:		
Compiler Pack	99	75
Development System	249	199
Repertoire	149	135
TopSpeed Modula-2:		
B-Tree Toolkit	149	135
Communications Toolkit	149	135
Compiler Kit	100	89
DOS 3-Pack	200	179
TechKit	60	55
VID	60	55

OPERATING SYSTEMS

	LIST	OURS
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Interactive 386/ix (complete)	1095	989
Multi-User	1445	1299
Microport Sys. V/386 (comp.)	899	799
PC-MOS 386 3.0 (1-user)	195	179
SCO 286 XENIX (complete)	1295	1099
SCO 386 XENIX (complete)	1595	1269
Wendin DOS	139	109
PCNX	99	80
PCVMS	139	109

OS/2 TOOLS

	LIST	OURS
Brief	195	CALL
Btrieve	595	449
Epsilon	195	159
Greenleaf DataWindows	395	309
GSS Graphics Toolkit	595	519
HALO	695	489
MKS Toolkit	495	439
MS OS/2 Present. Mgr. Toolkit	500	349
Multiscope	299	249
Panel Plus	495	395
Paradox OS/2	725	543
Topspeed Modula-2	195	179
Vitamin C	345	279

PASCAL LANGUAGE

	LIST	OURS
Asynch PLUS	149	115
B-tree Filer	125	99
MS QuickPASCAL	99	69
Object Professional	150	119
Power Screen 1.1	149	109
Power Tools PLUS/5.0	149	109
Topaz	75	67
Turbo Analyst	99	79
TurboMAGIC	199	179
Turbo Pascal 5.5	150	105
Turbo Pascal 5.5 Professional	250	175
Turbo-Plus 5.5	150	129
Turbo Professional 5.0	125	99

PROTOTYPING

	LIST	OURS
Dan Bricklin's Demo II	195	159
Instant Replay III	150	135
Show Partner F/X	350	319
Soft Demo	80	70

SOURCE MAINTENANCE

	LIST	OURS
MKS Make	149	129
MKS RCS	189	159
Personal PVCS	149	125
PolyMake	149	125
Professional PVCS	395	335
Seidl Version Manager	300	269
TLIB	100	90
5 Station LAN	300	259

WINDOWS (MS) TOOLS

	LIST	OURS
Actor	495	429
Case:W	795	759
C-Talk/Views	450	375
dBFast/Windows	249	229
MS Windows Development Kit	500	349
Whitewater Resource Toolkit	195	169
WinTrieve	395	339

ADDITIONAL PRODUCTS

	LIST	OURS
Baler Spreadsheet Compiler	495	459
Derive	200	179
Inside!	125	109
Opt-Tech Sort	149	129
Paginate	100	89
PC/Forth +	250	225
PC Metric	199	185
PC Scheme	95	79
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Source Print	99	89
Tree Diagrammer	99	89

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For more details, see our ad in this magazine.

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Paradox 3.0	725	509
SideKick Plus	200	139
Turbo Assembler/Debugger	150	105
Turbo Basic	100	69
Turbo C 2.0	150	99
Turbo C 2.0 Professional	250	169
Turbo Pascal 5.5	150	105
Turbo Pascal 5.5 Professional	250	175
Turbo Prolog	150	105
Turbo Prolog Toolbox	100	69
CREATIVE PROGRAMMING		
VCScreen	149	115
Vitamin C	225	165
for OS/2	345	279
Reference Database	50	CALL
DIGITALK		
Smalltalk/V	100	85
Communications	50	45
EGA/VGA Color Extension	50	45
Goodies #1, #2 or #3	50	45
Smalltalk/ V 286	200	169
Smalltalk/ V PM	500	425
FAIRCOM		
c-tree	395	315
w/ r-tree	650	519
w/ r-tree, d-tree	CALL	CALL
d-tree	495	395
r-tree	295	239
GSS		
GSS*CGM Metafile Interpreter	295	249
GSS*GKS Kernal System	595	519
GSS*GPS Plotting System	395	329
GSS Graphics Devel. Toolkit	595	519
XVT	595	509
IGC		
VM/386	245	199
VM/386 Multi-User	895	759
VM/386 NetPak	150	119
MEDIA CYBERNETICS		
Dr. HALO III	140	101
HALO	395	279
HALO DPE	195	139
HALO for MS Developers	595	399
HALO for OS/2	695	489
HALO Programmer's Workbook	80	59
HALO Window Toolkit	595	419
MICROSOFT		
MS BASIC/6.0	295	199
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MS COBOL	900	629
MS FORTRAN	450	299
MS Macro Assembler	150	99
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MS OS/2 Softset	150	105
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MS QuickPASCAL	99	69
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MS Windows/386	195	135
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MORTICE KERN SYSTEMS		
MKS Awk	99	85
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MKS Make	149	129
MKS Make for OS/2	249	209
MKS Programming Platform	665	565
MKS RCS	189	159
MKS RCS for OS/2	395	335
MKS SoftQuad Publishing Sys.	495	469
MKS Software Mgmt. Team	299	255
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MKS Toolkit V3.1 for OS/2	495	419
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Btrieve Single-User	245	185
Btrieve for DOS 3.1 Networks	595	449
Btrieve for OS/2	595	449
Btrieve for XENIX	595	449
C Network Compiler	695	525
C Network Compiler/ 386	995	799
NetWare C Interface for DOS	295	239
NetWare MHS	100	79
NetWare MHS Interface Guide	145	129
NetWare RPC	CALL	CALL
NetWare RPC for OS/2	CALL	CALL
NetWare SQL	595	449
NetWare System Calls for DOS	195	159
XQL	795	599
Xtrieve PLUS	595	459
Xtrieve PLUS for OS/2	595	459
PERISCOPE		
80286 Flex Cable Kit	200	179
80386 Flex Cable Kit	400	359
Periscope I/OK	545	459
Periscope I/512K	795	675
Periscope II	175	129
Periscope II-x	145	109
Periscope III/10 MHz	1395	1179
Periscope III PLUS/OK	1745	1479
Periscope III PLUS/512K	1895	1595
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PolyDoc	199	169
PolyLibrarian	99	85
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PolyXRef	99	85
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w/ dBRIEF	275	CALL
C-Worthy	195	CALL
w/ forms	295	CALL
w/ forms and source	495	CALL
dBRIEF	95	CALL
WHITEWATER GROUP		
Actor	495	429
Language Extensions I	99	85
Whitewater Resource Toolkit	195	169
WinTrieve	395	339
ZORTECH		
Zortech B-Tree Tools	80	72
Zortech C	90	79
Zortech C Debugger	90	79
Zortech Pro Screen Tools	70	63
Zortech C Video Course	300	269
Zortech C Windows	70	63
Zortech C++	200	165
Developer's Edition	450	385
Zortech C++ Debugger	150	129
Zortech C++ Tools	150	129
Zortech C++ Video Course	CALL	CALL

PROGRAMMER'S POLICIES

Phone Orders
Hours 9 AM-7 PM EST. We accept MasterCard, Visa, American Express. Include $4.00 per item for shipping and handling. All shipments by UPS ground. Rush service available.

Mail Orders
POs by mail or fax are welcome. Please include phone number.

International Service
Phone number required with order. Call or fax for additional information.

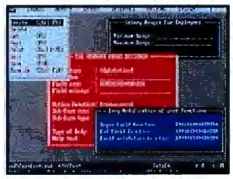
Dealers and Corporate Accounts
Call for information.

Unbeatable Prices
We'll match nationally advertised prices. (Subject to same terms and conditions.)

Return Policy
30-day no-hassle return policy. Some manufacturer's products cannot be returned once disk seals are broken.

VERMONT VIEWS

C-PROGRAMMERS! Would you like to double your productivity and have FUN too? Vermont Creative Software has the answer with the imminent release of the Vermont Views Designer.



Vermont Creative Software

This intuitive, menu-driven, screen generator taps the resources of the 650 pre-coded functions of the Vermont Views libraries. Customize data entry forms, choice lists, menus and more. Our customers around the world will be celebrating this powerful enhancement of Vermont Views. See our ad in this magazine for more details on how you can join the party...and try out Vermont Views with the Designer.

List: $395 ***Ours: CALL***

TURBO C 2.0

The Turbo C 2.0 optimizing C compiler with the integrated source-level debugger includes the compiler, editor, and debugger.

Turbo C 2.0 is fast, compiling your code better than 16,000 lines per minute! The integrated source-level debugger allows you to set multiple breakpoints, watch variables, and evaluate expressions–all from inside your integrated Turbo C environment.

Other features include: support for six memory models; in-line assembler; automatic dependency checking; and more than 430 optimized functions. The editor even has EMS support.

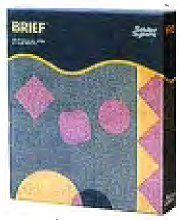
BORLAND

List: $150 ***Ours: $99***

BRIEF 3.0 - The Programmer's Edition

Edit Your Programs More Productively Than Ever Before

The program that set the standard for program editing continues to lead the industry. Introducing BRIEF 3.0. New features include: multiple keystroke macros, a new C-like macro language, a source level macro language debugger for both macro languages, "smart" indenting and template editing for Ada, C, Cobol, BASIC, FORTRAN, Modula-2, and Pascal, and the ability to "zoom" your current window to full screen size. You'll also get the features over 50,000 current users have come to rely on: unlimited windows, Undo, compile within BRIEF, a LISP-like macro language, and much more.



Solution Systems

List: $199 Ours: CALL

VM/386 & NetPak Bundle

VM/386, the PC Magazine Technical Excellence Award-Winning multi-tasking product, does wonders on networks working with the new companion product, 386 NetPak. Each one of the multiple DOS sessions running under VM/386 can access network files and printers through the NetPak software. And you can run larger memory-hungry applications such as CAD or Desktop software without ever leaving the network. If you're running on a network, this bundle is a must!

IGC

VM/386 List: $249 Ours: $199
NetPak List: $150 Ours: $119
Together: $269

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Programmer's Paradise

Circle 263 on Reader Service Card

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CONNECTIVITY

An MNP Modem for Your Pocket

The latest in a line of pocket-size communications packages, Touchbase Systems' WorldPort 2400/MNP incorporates Microcom MNP Class 5 error correction and data compression in a package that measures 1 by 5 by 3 inches and weighs just 7½ ounces. The company claims it's the smallest (and lightest) MNP-5 modem available.

As with all Touchbase modems, you can power the WorldPort 2400/MNP off a single standard 9-volt battery or from an (included) AC adapter. It's backward-compatible with both Bell and CCITT transmission protocols, and it has an internal speaker as well as LED indicators for high speed, MNP, carrier detect, and low battery.

The WorldPort 2400/MNP is fully compatible with the industry-standard AT command set. And MNP 5 gives you an effective throughput of 4800 bps when you use it to transfer text files. It's also compatible with systems that use MNP Class 4 (without data compression).

The modem includes its own internal nonvolatile RAM, in which you can store two different configuration profiles and four telephone numbers. For on-the-road use where you can't plug the modem into a phone jack, the company offers an acoustic coupler that works with telephone handsets and lets you use the WorldPort 2400/MNP at 300 and 1200 bps.

Price: $499; acoustic coupler, $79.95.
Contact: Touchbase Systems, Inc., 160 Laurel Ave., Northport, NY 11768, (516) 261-0423.
Inquiry 1154.

Touchbase Systems' WorldPort 2400/MNP pocket modem features MNP-5 data compression and error correction.

Put a Token Ring in Your Pocket

Xircom, the folks who brought you the first pocket-size stand-alone Ethernet adapter, now has a version for those who need to connect a laptop or desktop computer to an IBM Token Ring network.

Dubbed the Pocket Token Ring Adapter, the compact unit (about the size of a garage door opener) offers you the same plug-in-and-play capabilities of Xircom's Ethernet adapter. Like its brother, the PTRA plugs into any standard parallel printer port. Then you plug in the 4-Mbps Token Ring cabling to the other end. It's particularly useful for networking if you have a computer without any open expansion slots.

According to Xircom, the PTRA is possible because of Texas Instruments' new two-chip Token Ring chip set, which just became available. The entire PTRA consists of just five chips, including 128K bytes of on-board RAM. The company says it is working on a 16-Mbps Token Ring model and will have a pocket-size ARCnet adapter available in early 1990. Other versions for all major LANs will follow shortly thereafter.

Price: $795.
Contact: Xircom, Inc., 22231 Mulholland Hwy., Suite 114, Woodland Hills, CA 91364, (818) 884-8755.
Inquiry 1153.

SAA Interface, Security, and WAN Upgrade This Network Scheduler

Network Scheduler provides group calendars and appointment books for network users. The upgraded version, Network Scheduler II, provides a Systems Application Architecture–compatible common user interface and improved security.

Other enhancements include support for cc:Mail, 3Com's 3+Mail, Da Vinci Systems' MHS Link, and Consumer Software's Network Courier.

Price: Eight-user, $495; 25-user, $695; 50-user, $995.
Contact: Powercore, Inc., One Diversatech Dr., P.O. Box 756, Manteno, IL 60950, (815) 468-3737.
Inquiry 1158.

Toshiba Makes the Mac Connection

Toshiba's new software program, MacMatrix, lets you hook your Mac to one of Toshiba's 24-pin letter-quality printers.

The software comes with a cable that connects a Toshiba SL or SX printer to a Mac Plus, SE, SE/30, II, IIcx, or IIx with System 6 or higher.

The driver supports four scalable outline fonts (Courier, Helvetica, Symbol, and Times Roman) in point sizes from 6 to 127, according to Toshiba. The driver also supports bit-map fonts and object-oriented graphics.

Price: $49.
Contact: Toshiba America Information Systems, Inc., Computer Systems Division, 9740 Irvine Blvd., Irvine, CA 92718, (714) 583-3000.
Inquiry 1155.

Create a Menu

LAN system administrators can use Perfect Menu 2.0 to create a different menu for each person on the network.

International Computer Group says that the LAN version works with all NetBIOS-compatible LAN operating systems. The basic single-user program lets you customize your menu.

Perfect Menu runs in nonresident mode, even when you use E-mail, usage tracking, and screen blinking.

Price: Basic single-user, $49.95; business single-user, $84.95; five-user, $195.95; unlimited users on one file server, $349.95.
Contact: International Computer Group, Inc., 18520 Office Park Dr., Gaithersburg, MD 20879, (301) 670-7007.
Inquiry 1157.

continued

GO AHEAD, MAKE YOUR DAY

Point-and-Pick Your Applications
Choose the application you need quickly and easily directly from the menu—or even another application!

Run Several Tasks at Once
Switch instantly between active tasks in different applications at the touch of a keystroke!

Move Data Between Applications
Share data easily between applications like SCO™ Lyrix,® SCO Professional,® and SCO Integra™ with the electronic Clipboard!

Print While You Work
Move on to your next job while your last one is printing out—on a local or shared workgroup printer!

Link Up Your Business with Electronic Mail
Exchange messages and files—even spreadsheets and graphics—across the office or around the world!

Talk Across The Office
Instantly converse with other system users, screen-to-screen, with the handy Intercom!

Locate Business Contacts Instantly
Store, update, find, and sort addresses and phone numbers quickly and easily with the time-saving Directory!

Schedule Meetings and Resources
Check others' Calendars online for available times—then schedule and notify them automatically!

Calculate Within Any Application
Put the four-function, "running-tape" capabilities of an online Calculator right at your fingertips!

Add Only the Applications You Need
Build your own customized solution by adding individual applications as you need them!

WITH THE SCO PORTFOLIO WORKGROUP SOLUTION

Get the competitive edge with the SCO Portfolio™ integrated workgroup solution!

Teamed with the world's most popular UNIX® System—SCO System V—the SCO Portfolio solution turns the 386™ personal computer into a workgroup powerhouse.

What's more, users only need to know how to use their familiar applications in order to put the amazing power of the UNIX System to work immediately.

With SCO Portfolio and the SCO Portfolio family of business applications, everyone in a workgroup can perform virtually any business task—from writing reports and creating financial analyses, to scheduling meetings and exchanging messages—far more productively than ever.

And all using a single, standard—and cost-effective—386-based PC!

Get started today with SCO Portfolio Suite, and get all the advantages of a fully-integrated office system without compromising the functionality of full-featured business applications—all in one economical package.

SCO Portfolio Suite integrates the powerful SCO Lyrix word processing system, the SCO Professional 1-2-3® workalike, and the SCO Integra industry-standard-SQL database, with SCO Portfolio's convenient desktop tools, customizable menu system, and electronic clipboard—and lets you add any other software of your choice under its easy-to-use menu, as well.

Contact your SCO authorized supplier or call (800) 626-UNIX (626-8649) for more information about SCO Portfolio and SCO Portfolio Suite and find out how easy it is to make your day—today!

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Circle 289 on Reader Service Card

CONNECTIVITY

Persoft Emulates VT320 and VT240

Persoft introduced a network version of its VT320 text terminal emulation software package and version 3.0 of its multiuser DEC VT240 graphics terminal emulator. Both are also available in single-user versions.

Both SmarTerm 240 and SmarTerm 320 provide customized setups for each user and support any number of nodes. Supported networks include Novell's NetWare, Banyan's VINES, DECnet DOS, IBM LANACS, and 3Com/Bridge's Etherterm.

SmarTerm 320's emulation capabilities include downloadable characters used by WordPerfect and Oracle, 132-column text screens, and double-high, double-wide characters. A background mode allows file transfer and other emulator tasks while you're in your DOS application. To help you use DEC keyboard functions on a standard IBM PC keyboard, Persoft included a WordPerfect driver and extended keyboard remapping.

SmarTerm 240 version 3.0 is a multiuser DEC VT240 graphics terminal emulation package with LK250 keyboard support.

SmarTerm 240 also includes LK250 keyboard support with this latest update. It now supports all of DEC's VT240 ReGIS graphics command language, permitting a full-screen display of a ReGIS image on VGA, EGA, CGA, and Hercules systems.

Both SmarTerm 240 and 320 are priced in single-user versions, five-user versions, and add-on kits for five additional users.

Price: 320 individual package, $195; 320 file server, $895; file server add-on kit, $550; 240 individual package, $345; 240 file server, $1495; 240 file server add-on kit, $995; trade-up from SmarTerm 220 to 320, $97.50.

Contact: Persoft, Inc., UW Research Park, 465 Science Dr., Madison, WI 53711, (608) 273-6000.

Inquiry 1161.

Modem Mail, Phone Home

Modem Mail is a NetBIOS-compatible program that lets you use a modem to send and receive E-mail messages to and from your office LAN.

Modem Mail 2.0 supports 9600-bps (V.32) telecommunications—twice the speed of version 1.0.

On your remote IBM PC, you'll need at least 256K bytes of RAM, a modem, and a copy of Modem Mail 2.0. On your dedicated LAN workstation that receives calls from Modem Mail 2.0, you need a modem, the base E-mail package called Network Courier 2.0, and Modem Mail Postoffice software (which provides administrative functions like a regular post office).

One other enhancement to Modem Mail 2.0 is the function of Mailbag Maintenance, the company says. This lets you pick from all your messages the ones you want to download. Early next year, the company promises to have a package for Macintosh connectivity.

Price: Network Courier 2.0 and Modem Mail Postoffice, $1490; Modem Mail 2.0 remote-user software for each node, $95.

Contact: Consumers Software, Inc., 603–73 Water St., Vancouver, BC, Canada V6B 1A1, (604) 688-4548.

Inquiry 1164.

continued

Manipulate Database Files Locally, Remotely, or Both Simultaneously

Record-Trans 2.0 allows you to use a modem or a LAN for querying remote dBASE III or IV, Clipper, or FoxBASE database files and transferring specific database records rather than entire files.

Once you receive the files, at rates between 300 and 9600 bps, the modem version of Record-Trans lets you send back multiple records to multiple database files, thus upgrading several database files at once. Upgrading multiple databases in multiple remote locations is the next step. And with an Advanced Editor function, you can create batch files that both connect and update many remote database locations without database operator intervention. Record-Trans also has log files to time-stamp activities in the systems.

The LAN version is compatible with any NetBIOS-compatible network like Novell's NetWare, Banyan's VINES, 3Com's 3+ and 3+Open, and so on. It has a Record Locking function that allows multiple users on your LAN simultaneous access to the database.

Both the modem- and LAN-compatible versions of Record-Trans allow simultaneous access to remote and local databases, with simultaneous display in two windows on your screen. With this function, you can add, delete, and update records to the two databases at the same time. You can also cut and paste between the two databases.

Specific system requirements include MS-DOS 3.0 or higher, 512K bytes of RAM, a serial adapter, and a Hayes-compatible modem or NetBIOS-compatible network operating system.

Price: Modem version, $250 per node; LAN, $499.

Contact: Database & Datacom Solutions, 3611 South Harbor, Suite 215, Santa Ana, CA 92704, (714) 434-1000.

Inquiry 1156.

How to plan your LAN.

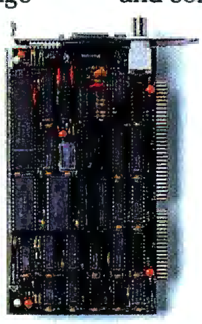
You'll need a pencil.

That's to write down the telephone number on the next page. Which will connect you with Samsung's nationwide network of resellers. And the Samsung/Novell co-labeled line of LAN hardware.

It's pretty much that simple.

With one call you can plan on substantial savings over the big name computers which, despite high clock rates and even higher price tags, are not really optimized for networking.

And you can plan on 100 percent compatibility with all versions of Novell's NetWare®, because Samsung's LAN hardware was co-designed by Novell. Just like the label says.



THE TESTING WENT IN BEFORE THE LABEL WENT ON.

Both the Samsung 386AE and PCterminal/286 have been tested exhaustively and certified by Novell for compatibility with all popular networking hardware and software products. As a matter of fact, Samsung's 386AE is one of 3 fileservers certified by Novell to run NetWare 386.

For example, engineers at Novell successfully tested the PCterminal/286 LAN Workstation in no less than 1200 different network configurations… with 50 units running at once! That's a claim no other computer manufacturer can make.

NETWORKING VS. NOTWORKING.

What's the difference? Take our 386AE Fileserver, for instance. It includes Novell's Advanced BIOS, and eight expansion slots to accommodate multiple network interface cards and disk controllers. Plus an oversize power supply capable of driving dual high capacity hard disks and tape

back-up system. Plus 4 megabytes of main memory for disk caching.

Then there's Samsung's PCterminal/286 Diskless Workstation which includes a built-in Ethernet interface and Novell's Remote Boot EPROM.

And not to be overlooked is our 16-bit SE2100 Ethernet Interface Card which provides up to twice the throughput for the price of an 8-bit card.

THE SAMSUNG COMMITMENT.

With 4 million monitors and half a million PC and LAN computers sold in 1988 alone, it's clear that Samsung has made a serious commitment to the marketplace. In all, Samsung offers no less than nine different PC and LAN computer models with seventeen color and monochrome monitors! And, as a 31-billion dollar international corporation, Samsung has the resources to provide continuous support for its customers.

So why not begin your network planning today? For the name of the Samsung reseller nearest you, write:
SAMSUNG, 3655 North First Street, San Jose, CA 95134, or call **1-800-446-0262.**

SAMSUNG

Circle 287 on Reader Service Card (DEALERS: 288)

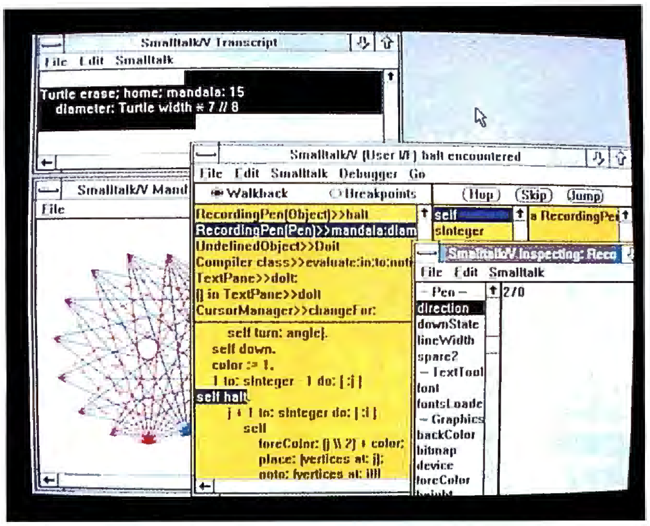
Smalltalks for PM and the Mac

Digitalk's latest Smalltalks offer object-oriented programming for Presentation Manager and the Macintosh environments. Smalltalk/V PM, a development environment for OS/2's Presentation Manager, gives you access to PM features such as Dynamic Data Exchange and Dynamic Link Libraries, letting you integrate and pass data to and from PM tools and other applications. Most important, it compiles incrementally to machine code, giving immediate notice of an error.

Smalltalk/V Mac 1.1, an upgrade of the Mac version, now includes a facility for returning an error code immediately upon failure, the company reports.

Digitalk claims that the Smalltalk/V PM source code is compatible with Smalltalk/V 286 and Smalltalk/V Mac, allowing you to port applications among the different environments. No run-time fees are associated with the PM version.

Smalltalk/V PM requires an IBM PC AT with OS/2 1.1 or higher and PM. Smalltalk/V Mac 1.1 runs on the Mac Plus.
Price: $499.95; Smalltalk/V Mac, $199.95.
Contact: Digitalk, Inc., 9841 Airport Blvd., Los Angeles, CA 90045, (213) 645-1082.
Inquiry 1116.



Smalltalk/V PM in action, debugging a drawing and stopping after each iteration.

Expert System Under X Window

Knowledge Craft, the advanced toolkit for building expert systems, will soon be available running under the X Window System on the MicroVAX II and Sun workstations, Carnegie Group reports. In addition to running under X Window and providing greater portability to other systems running under X Window, Knowledge Craft 4.0 will feature an object-oriented programming system and an Interface Development System (IDS) with graphics and a rapid prototyping capability. Carnegie Group reports that the new prototyping methodology is a shell that will let you develop knowledge-based applications more rapidly.

Carnegie Group also released KC Prime, which uses the basic components of Knowledge Craft (including the Carnegie Representation Language, its Workcenter, and the IDS) for developing knowledge systems that require representation support but may not need rules.

To develop a system with Knowledge Craft, you'll need about 16 megabytes.
Price: Knowledge Craft, between $16,000 and $36,000; KC Prime, between $8000 and $16,000.
Contact: Carnegie Group, Inc., Five PPG Place, Pittsburgh, PA 15222, (412) 642-6900.
Inquiry 1119.

Lattice Adds Numerous Features to Its C Compiler

Besides full compatibility with both DOS and OS/2, Lattice says version 6.0 of Lattice C includes major compiler enhancements, a global optimizer, new programming utilities, and many new library functions.

The company claims that the package has better performance than Microsoft's or Borland's versions of C. The better performance, according to Lattice, results from the new global optimizer, automatic register variable support, in-line function support, and optimized libraries.

The Lattice C development system now includes LASM, a new macro assembler that has special support for 80386-based systems. Lattice says it's compatible with MASM (Microsoft's assembler). LASM's output is compatible with CodePRobe (included with 6.0), so that you can debug assembly language programs at the source level.

New utilities with version 6.0 include an overlay linker, a Make utility, an LBIND utility, and several "Unix-like" tools, including EXTRACT, BUILD, DIFF, GREP, SPLAT, TOUCH, and WC (word count). The company says that Lattice C works with DOS 2.0 and higher and all versions of OS/2.
Price: $250; upgrade from version 3.4, $90; upgrade from version 3.3 or lower, $115.
Contact: Lattice, Inc., 2500 South Highland Ave., Lombard, IL 60148, (800) 444-4309 or (708) 916-1600.
Inquiry 1117.

Create Expert Systems Under Windows

Kappa is a programming environment that you can use to simulate real-world situations and solve problems in business, science, and engineering. The program provides a library of more than 200 functions and supports three techniques for knowledge representation and reasoning: functional programming, object-oriented programming (OOP), and rule-based reasoning.

All three techniques are integrated in Kappa. You can invoke rules through functions and methods, send messages from functions and rules, and so on. The program also includes a set of tools for representing problems in graphical terms.

Kappa runs under Microsoft Windows on the IBM PC AT or higher with 640K bytes of RAM and a hard disk drive. By the time you read this, a Macintosh version should be available. A Unix version running under X Window should be available in the first quarter of 1990.
Price: $3500.
Contact: MegaKnowledge, Inc., One Kendall Sq., Building 600, Second Floor, Cambridge, MA 02139, (617) 494-9234.
Inquiry 1118.

continued

QNX®

The OS for over-achievers™

QNX programmers have a decided advantage.

You see, people who use QNX enjoy the freedom that comes only with a flexible, modular OS. They appreciate the elegance of a **message-passing architecture**. And they marvel at the fact that QNX runs so lean—under 150K—yet out-performs any other PC operating system.

QNX users never worry about whether their applications will make it at runtime, because they know QNX has proven itself again and again in the real world.

It's no wonder that QNX users have achieved so much since the product was first released for the PC in 1982: over 80,000 systems installed in 47 countries world-wide, in all kinds of applications—from making cars to selling books to handling online credit card transactions.

One reviewer dubbed QNX "The multi-everything OS." Now, you might expect multiuser and multitasking, but realtime? *And* integrated networking? *And* true distributed processing? Best of all, these terms take on a new meaning with QNX.

Multiuser, for instance, means up to 32 terminals per micro. **Multitasking** cashes out as 150 tasks per machine. **Realtime** means not only priority-driven, preemptive task scheduling, but also speed: at 6,896 task switches/sec on a 16MHz 286, QNX is at least a full order of magnitude faster than a typical UNIX system. **Integrated networking** means you won't need yet another layer of software to set up a LAN, and you can use *any mix* of Intel-based micros—from vintage '81 PCs to PS/2s.

Distributed processing with QNX sounds too good to be true. But it is: *Any task can access any resource*—programs, files, devices, even CPUs—without going through the bottleneck of a central file server.

Besides the satisfaction that QNX developers get from using a fast, powerful, and flexible OS, did we mention that they also enjoy *free technical support?*

If you're wondering why you don't already know all about this great OS, you could try asking the over-achievers who are smugly guarding the secret of their success.

Better yet, give us a call. We'll tell you everything you need to know to become an over-achiever yourself.

For more information or a free demo disk, please phone (613) 591-0931.

Quantum Software Systems Ltd., 175 Terrence Matthews Crescent, Kanata, Ontario, Canada K2M 1W8

Circle 275 on Reader Service Card

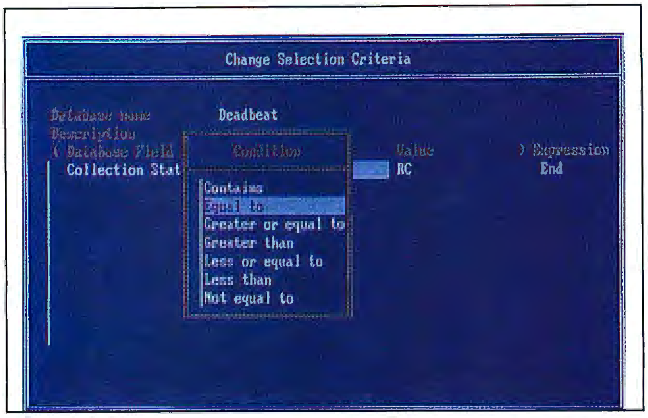
Utility Eases Database Access for WordPerfect Users

Unless you have an integrated word processor and database product like Symphony or Microsoft Works, the everyday business task of linking data from databases to word processor-generated documents can get complicated. You have to insert the appropriate merge codes in your document and then extract the correct data from the database and dump it into a correctly delimited ASCII file.

Perfect Complement 2.0, a WordPerfect accessory, automates the database merge process between dBASE, Paradox, Lotus, R:base, and Symphony databases and WordPerfect documents. When used on an IBM PC with the Intel Connection Co-Processor Board installed, the program supports fax-merge operations. The company has also introduced a version that works with Oracle databases.

Perfect Complement provides a simple menu-driven system for defining merge fields and selection criteria, and for prompting you to enter appropriate data values in the form letter. The interface allows you to create libraries of documents that automatically access the specified database. You can attach conditions (such as an overdue date or insufficient funds value) so that only those records satisfying the conditions are merged into the document.

Price: $149.95; Oracle version, $295.
Contact: Perfect Complement Corp., 4979 Mercantile Rd., Baltimore, MD 21236, (800) 444-9544 or (301) 256-2000.
Inquiry 1101.



Perfect Complement, showing its external database reference.

Data in and out of Lotus 1-2-3 Without the Hassle

A program called RoundTrip can help you get data in and out of Lotus 1-2-3 by creating worksheets from ASCII- and dBASE-formatted reports and Symphony worksheets. The program can convert and update multiple worksheets into one worksheet and vice versa, Circle Systems reports.

With RoundTrip and a communications program, you can move data from any mainframe report file into a worksheet, complete with working formulas to perform what-if forecasting. You set up the process just once with a few lines of simple code.

RoundTrip can read a payroll file, insert names and pay rates into the model, produce sum formulas, and construct separate worksheets or a single worksheet with subtotals for each division. Since you don't have to reenter data by hand, the program speeds up your work, and your data is transferred without errors.

RoundTrip works with columnar or delimited ASCII and supports Novell, DCA, Attachmate, Walker Richler Quinn, IBM, and Sun file transfer programs. It runs on the IBM PC with 256K bytes of RAM, Symphony, dBASE III or higher, and any version of 1-2-3 up to release 2.2. Circle expects to provide an upgrade to release 3.0 free of charge by the end of the year.

Price: Standard version (up to 12 worksheets at once), $195; unlimited spreadsheets, $695.
Contact: Circle Systems, 10001 Fourth Ave., Suite 3200, Seattle, WA 98154, (800) 456-4451 or (206) 682-3783.
Inquiry 1102.

Contact Database with Branched Scripts

LetterMaster Advanced is a customizable contact management database with a scripting system that lets you follow on-screen scripts during a sales phone call or presentation. The scripts are branched, allowing you to call up a response to any question raised during the presentation. According to Dilg Publishing, the number of branches you can create is limited only by available system memory.

LetterMaster Advanced's File Browser is dBASE-compatible and displays records in a table layout. Other features include contact record keeping, free-form notes with date and time stamping, an auto-dialer, a text editor and word processor, expense tracking, and a library of letters.

LetterMaster Advanced is available in a five-user LAN pack. The program runs on the IBM PC with DOS 3.0 or higher, a hard disk drive, and 640K bytes of RAM.

Price: $495; LAN version, $395.
Contact: Dilg Publishing, P.O. Box 110216, Arlington, TX 76007, (800) 338-9181 or (817) 860-0155.
Inquiry 1103.

continued

Time Management Hits Presentation Manager

Instead of conventional calendars and to-do lists, Active Life, a time management system for OS/2, flows all task and appointments into daily schedules. TimeStar Systems claims that this "dynamic system" is a far better method of planned sequencing and time allocation than conventional methods.

Additional features include alarms, week-at-a-glance pop-up calendars, historic archiving, and a companion database manager. This graphics and text database has auto-sorting, title/text searching, automatic telephone dialing, and a built-in word processor. You can also place graphics or scanned images alongside notebook text.

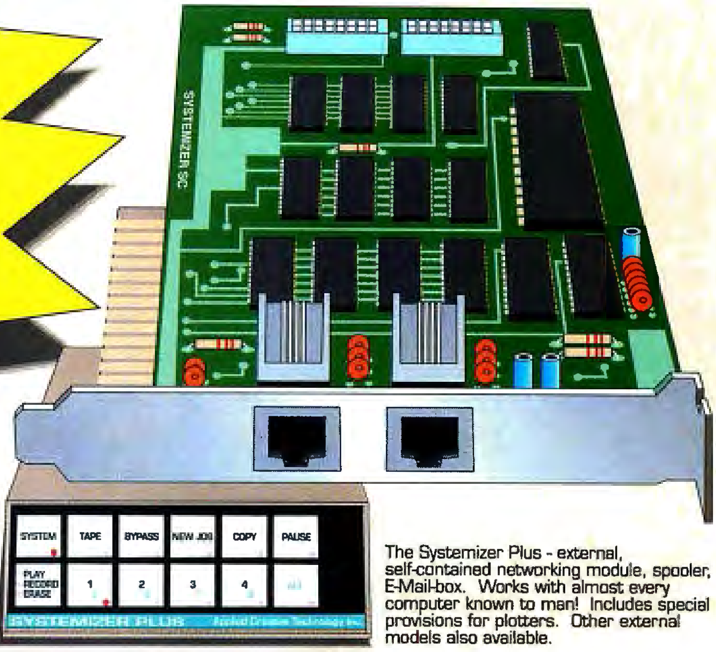
Active Life is a port of the Windows version, known previously as TimeStar 2.0, and requires an IBM PC AT with OS/2 1.1 or higher.

Price: $199.
Contact: TimeStar Systems, 1803 Mission St., Suite 8, Santa Cruz, CA 95060, (800) 326-4391 or (408) 983-4930.
Inquiry 1106.

NEW Slot Card Systemizer SC!

Systemizing
The truly universal LAN alternative...

The Systemizer SC - features memory resident printer controller, spooling, E-Mail and file transfer. For all MS-DOS® PC's and compatibles.



The Systemizer Plus - external, self-contained networking module, spooler, E-Mail-box. Works with almost every computer known to man! Includes special provisions for plotters. Other external models also available.

Up to 31 users can...

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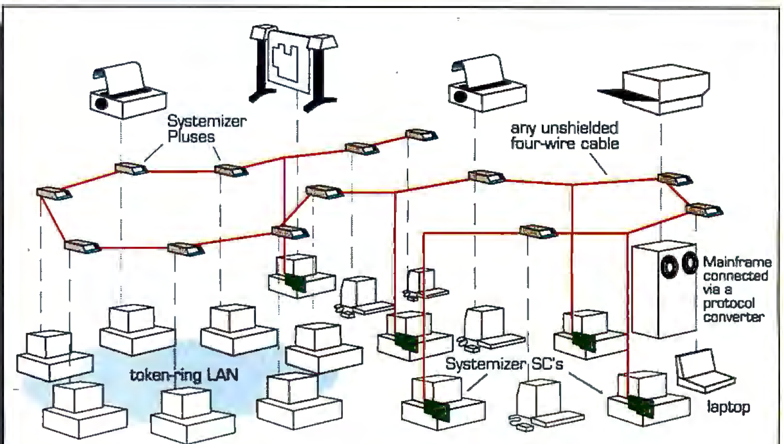
- Share Plotters
- Share a Modem
- Exchange E-MAIL
- Transfer Datafiles



Example: 17 micros, of various brands, *plus* a mainframe, all sharing printers, data and E-Mail via Systemizing. Note how some PC's on a token-ring LAN are also part of the Systemizer LAN.

Systemizing has become the connectivity standard at many of the world's largest corporations and throughout the federal government. Ten's of thousands are already in use. The new Systemizer SC is the latest model in Applied Creative Technology's line of Systemizing products, and it delivers what 95% of corporate computer users want from a Local Area Network— at far less cost and complexity, and yet with much more versatility.

Corporate computing managers prefer Systemizing over other connectivity methods because it offers:
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Choose OS/2 now and get rebates on memory and software. Also get a free upgrade to Version 1.2 until December 31, 1989.

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CAD AND GRAPHICS

To create this image, StrataVision 3d imported a DXF wire-frame file. The camouflage is from a two-dimensional PixelPaint map that was wrapped around the body.

3-D Graphics Program Uses 32-Bit Color QuickDraw

The StrataVision 3d graphics program works with 32-Bit Color QuickDraw and lets you import objects from CAD and paint programs, add objects from an image database, and use rendering techniques to create images with the quality of a photograph, Strata reports.

One of the program's graphics techniques, extrusion, lets you push a two-dimensional graphic through space to create a three-dimensional object. The program's rendering modes include wire-frame, flat shading, Gouraud shading, Phong shading, and ray tracing. You can rotate, stretch, and scale three-dimensional objects.

StrataVision 3d imports DXF, IGES, Super 3D, Swivel 3D, PICT, Encapsulated PostScript, and MiniCAD+ files. The program exports PICT and TIFF files. Attribute and object libraries will also be available, says Strata.

To run StrataVision 3d, you need a Mac II, IIx, IIcx, or SE/30 with 2 megabytes of RAM, a hard disk drive, System 6.0.3, and 32-Bit Color QuickDraw.
Price: $495; attribute library, $89; object library, $150.
Contact: Strata, Inc., 249 East Tabernacle, Suite 201, St. George, UT 84770, (801) 628-5218.
Inquiry 1121.

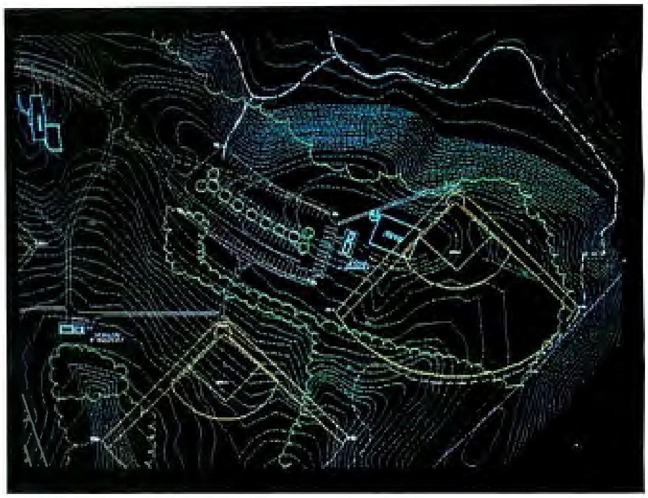
Built-in Scanner Control with PC Paintbrush IV Plus

PC Paintbrush IV Plus, ZSoft's newest version of its program for creating and retouching images, provides built-in scanner control, support for large images, and expanded and extended memory support. The program supports black-and-white, gray-scale, and color scanners, and if you use more than one scanner, you can save separate configuration files for each one for future use.

A prescan option lets you scan a full page at low resolution and select the portion of it that you want to scan at high resolution.

The program runs on the IBM PC with 640K bytes of RAM, DOS 3.0 or higher, a drawing device, and a hard disk drive.
Price: $199.
Contact: ZSoft Corp., 450 Franklin Rd., Suite 100, Marietta, GA 30067, (404) 428-0008.
Inquiry 1124.

continued



Peek/Smith used LandCADD's Site Planning module and Videoscapes to enter topographic information and plant materials to this baseball field.

100 Plant Images for LandCADD

LandCADD's Videoscapes, a visual database of plants for architects and civil engineers who use AutoCAD for site planning, contains about 100 pictures that you can access from within the AutoCAD drawing editor. Videoscapes works with LandCADD's Site Planning and Landscape Design add-ins for AutoCAD.

Videoscapes requires AutoCAD release 10 and LandCADD Site Planning and Landscape Design release 10.5 running on the IBM PC AT with 640K bytes of RAM, a hard disk drive, and a math coprocessor.

Price: $295.
Contact: LandCADD, Inc., 7519 East Highway 86, Franktown, CO 80116, (303) 688-8160.
Inquiry 1123.

Make Your Presentations Move with Animator

Autodesk is touting its Animator program as the best way to make a business presentation or training session come to life on an IBM PC with a VGA display. Animator lets you create, edit, and play full-length presentations in real time from your hard disk at up to 70 frames per second with up to 256 colors.

The program creates animations in five formats: cel animation, optical, polymorphic tweening, color cycling, and titling. Cel animations produce Disney-like animations, while polymorphic tweening is a form of object-oriented animation, where a square will gradually change into a star, for example. Color cycling animations are what you see on a TV weather report, with moving arrows and weather fronts.

The program requires an 80286-based PC or higher to create animations, but you can use an included public-domain player utility that will play animations on a standard IBM PC. If you have a VGA-to-NTSC card or conversion box, you can record to videotape. Animator requires 640K bytes of RAM and a hard disk drive.

Price: $299.
Contact: Autodesk, Inc., 2320 Marinship Way, Sausalito, CA 94965, (800) 525-2763 or (415) 332-2344.
Inquiry 1122.

continued

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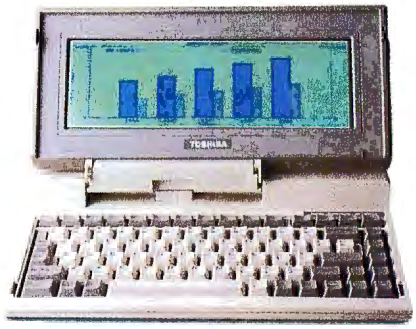
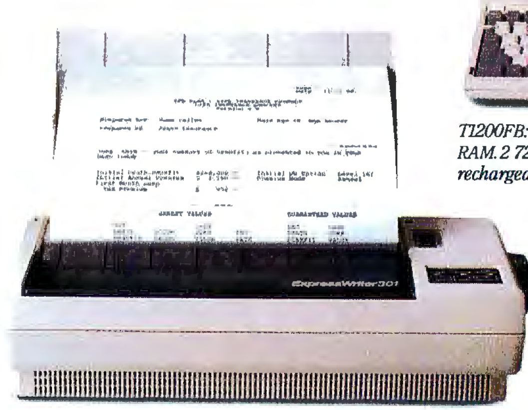
Page Laser12: 12 ppm, up to 3 paper bins, 750 sheet capability, Toshiba/Qume, Diablo, IBM & HP emulations.



T1000: 6.4 lbs, 4.77MHz 80C88, 512KB RAM expandable to 1.2MB. MS-DOS in ROM, 720KB 3½" diskette drive. Built-in RGB, parallel, serial and external drive ports.

P341SL: Wide carriage (up to 270CPL), 216/72 cps, advanced paper handling, 4 part forms.

T1200FB: 9.8 pounds, 9.54MHz 80C86, 1MB RAM. 2 720KB 3½" floppy drives, removable/rechargeable battery pack.



ExpressWriter 301: 4 lbs, letter-quality 24-dot print head, 60 cps, Toshiba/Qume and Epson LQ emulations, 5 resident fonts.

T3100e: 12MHz 80286, internal IBM slot, 20MB hard disk, gas plasma display, 1MB RAM expands to 5MB, 1.44MB 3½" diskette drive.

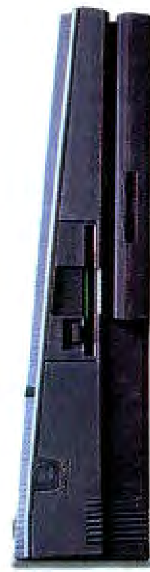
T5100: 16MHz 80386 microprocessor, 40 or 100MB hard disk, 2MB RAM expandable to 4MB. 14.6 lbs. Built-in EGA display with high resolution gas plasma screen.

P351SX: 360/120 cps, 24-pin letter quality, color option, Toshiba/Qume and IBM emulations standard, Epson & Diablo emulations optional.

great minds don't think alike.

T1600: 11.6 lbs, Battery-powered 12MHz 286, 20MB hard disk, 1.44MB floppy. 1MB RAM expands to 5MB, backlit EGA LCD, removable/rechargeable battery packs.

T5200: 20MHz 80386 processor, 2 internal IBM compatible expansion slots, 40 or 100MB hard disk, VGA display with external VGA monitor port, 2MB RAM expandable to 8MB.



T3200: 12MHz 286, 2 IBM compatible slots. 40MB hard disk, 1.44MB floppy, 1MB RAM expands to 4MB, EGA screen.

PageLaser6: 6 ppm. 512KB standard memory. Emulations: HP LaserJet Series II, IBM Proprinter XL24. 2 HP LaserJet compatible font slots, multiple purpose tray. 4,000 prints per month. 35 pounds.

ExpressWriter 311: 24-pin dot matrix, 180 cps draft/60 cps letter quality, 3 resident emulations (Toshiba/Qume, Epson LQ, IBM Proprinter), 16K buffer, 5 resident fonts plus card slots, 11 lbs.

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T1200HB: 10.8 lbs, 9.54MHz 80C86, 20MB hard disk, 1MB RAM, includes 384KB LIM-EMS. Removable/rechargeable battery pack.

P321SL/SLC (color): 216/72 cps, 24-pin letter quality, up to 360x360 DPI graphics, Toshiba/Qume and IBM emulations standard, Epson and Diablo emulations optional, 32KB print buffer, front panel controls, advanced paper handling.

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SCIENCE AND ENGINEERING

DADiSP 2.0, displaying raw data and several functions. Note that in the top middle window, a change in the raw data would change the maximum value in the annotation.

Data Analysis and DSP Spreadsheet

Spreadsheets are usually associated with the business world, but DADiSP 2.0 is a spreadsheet that lets you convert scientific data, run hundreds of analysis functions, and display the results next to the original data in up to 64 windows. As with a business spreadsheet, you can manipulate and link individual windows. A change in the original data is reflected in each linked graph. But instead of numbers or formulas in a cell, DADiSP windows (which you can zoom and scroll) contain entire waveforms.

DADiSP lets you take data in table, signal, waveform, and text formats and look at it from different points of view. One window can contain the imported waveform; a second window, its fast Fourier transform output; a third, several overlays of data; a fourth, a tabular view; a fifth, a three-dimensional plot; and so on. You can annotate each window, and a change in data is reflected in the annotation.

DADiSP 2.0 comes with hundreds of analysis functions, including signal arithmetic and calculus, peak finding, and frequency domain analysis. A macro definition facility lets you create new functions.

All numerical calculations are performed in 8-byte IEEE-standard double-precision math, DSP reports. A pipeline lets you run other programs from the DADiSP worksheet, including those written in FORTRAN, C, BASIC, Pascal, and assembly language. DADiSP 2.0 supports digital filtering, and a separate module, the DADiSP-488 driver, lets you control and transfer data from IEEE-488-based instruments.

DADiSP 2.0 runs on the IBM PC AT with DOS 3.0 or higher, 2 megabytes of extended memory, and a hard disk drive. It operates under Unix on the HP 9000 Series 300 and Concurrent and Sun workstations, but not under Xenix on the PC.

Price: $1695; workstation versions, $2995 and up; DADiSP-488, $195.

Contact: DSP Development Corp., One Kendall Sq., Cambridge, MA 02139, (617) 577-1133.

Inquiry 1109.

continued

Circuit Analysis with Seven Outside Connections

The ACNAP (AC Network Analysis Program) circuit analysis program for the Macintosh is a circuit simulator that analyzes up to 200 active and passive components and handles subcircuits with up to seven connections to the outside world.

The program supports unlimited-length keystroke macros; you can embed comments or instructions into the macro command and insert delays that wait for your input. With these macros, you can automate repetitive tasks or set up instructional sequences for later use by lesser-trained individuals, BV Engineering reports.

ACNAP performs Bode, Monte Carlo, sensitivity, noise equivalent bandwidth, spectra, component iteration, and worst-case analyses. You can create, combine, and edit component models and circuits that you save as single devices to a component library.

ACNAP works on the Mac 512K or higher.

Price: $349.95.

Contact: BV Engineering Professional Software, 2023 Chicago Ave., Suite B-13, Riverside, CA 92507, (714) 781-0252.

Inquiry 1110.

Data-Analysis Program Develops Math Models

MINSQ (for "minimum squares") is a least-squares parameter-estimation and data-analysis tool that you can use to develop math models by performing simulations with known parameter values, MicroMath reports. You can use it to fit parameter values in model equations to actual experimental data.

You can plot observed versus calculated values with data sets of up to 200 points. If your data has more than 200 points, a data sieve lets you use subsets of the data set by reading every *n*th point, for example.

MINSQ runs on the IBM PC with 640K bytes of RAM, a hard disk drive, and a graphics adapter. The program supports the 80x87 math coprocessor family. If you don't have a coprocessor, the program can emulate one. MINSQ can't read arbitrary text files.

Price: $179.

Contact: MicroMath Scientific Software, 2034 East Fort Union Blvd., Salt Lake City, UT 84121, (801) 943-0290.

Inquiry 1111.

Review, Cut, and Paste Waveform Files on the Mac

With WavEdit, you can review and edit large files of experimental data. You can open many data recordings and review them simultaneously, including any 8- or 12-bit files that can be saved in simple text or binary format.

Each recording appears as a chart-recorder-style display in a separate window; you can identify a region of interest and cut, copy, and paste your selection to a new file for display or to a desktop publishing program for incorporation into a publication or presentation. The program cannot delete or modify raw data.

WavEdit works on the Mac Plus, but a Mac II is better for large data files.

Price: $395.

Contact: World Precision Instruments, 375 Quinnipiac Ave., New Haven, CT 06513, (203) 469-8281.

Inquiry 1112.

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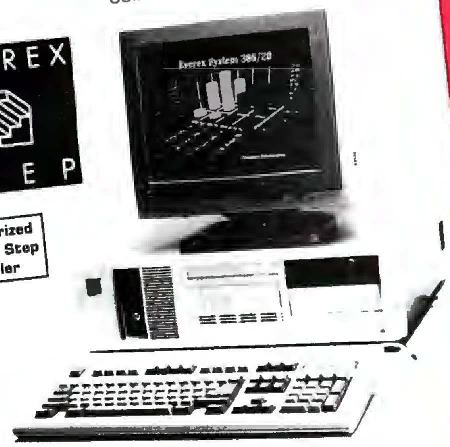

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Gates: DOS to Last "a Long Time"

An estimated 1300 people filled the Scottish Rite Memorial Temple to witness the second appearance of Bill Gates, president and CEO of Microsoft, at the Sacramento PC Users Group.

In August, Gates spoke on a number of topics ranging from DOS to rival company WordPerfect Corp. Speaking on Microsoft's plans for DOS, Gates said that while end users can't currently get upgrades to DOS directly from Microsoft, user demand for such a service is high enough that the company is seriously planning to work out its own upgrade system, perhaps by next year.

As for the current version of DOS (4.00), he said the major problem is its failure to be consistent with the EMS 4.0 paging specification, a problem that has since been corrected. "DOS can last for a long time to come," he said. "The second most popular operating system after DOS, which has 30 million users, is the Macintosh, which at this point has about 2.4 million users—less than 10 percent of the sales of DOS." He also said that Microsoft is committed to long-term coexistence with DOS and OS/2.

Gates said he thought Windows would be used increasingly with DOS to provide the graphical user interface that many people are eager to have. The similar user interface of Presentation Manager with OS/2 should start coming into its own in 1990, when he anticipates that over 1 million copies will sell.

Speaking on workstations versus microcomputers, Gates said the key differences are power, graphics resolution, and storage. He cited the forthcoming Intel 80486 systems as outperforming current workstations, which will further blur the distinction and cause the stratospheric prices of workstations to come down. The 32-bit memory addresses that are becoming available on microcomputers wipe out another distinction, he said. While OS/2 doesn't directly support the 32-bit features of the Intel 80386, Microsoft is working on it, and 32-bit operations will be supported in the next OS/2 developer's kit.

Gates also talked about rival company WordPerfect Corp. "They do a very good job with their products, and their word processor is number one. We're number two, and we do try harder." He praised WordPerfect's Alan Ashton and Pete Peterson. "Pete Peterson is the head of their sales activities—very aggressive and likes to give us a hard time. There's a guy named Jeff Raikes in charge of our office business unit whose job is to wake up every morning and think about Pete Peterson. And if he can't tell me the names and ages of all Pete's children, I'm very disappointed."—Reported by Tony Barcellos of SPCUG.

[Editor's note: *On December 20, starting at 7:00 p.m., Borland International is scheduled to demonstrate a*

continued

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APPLE TYPE				
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256K x 4 DIP	—	—	14.75	15.00
64K x 1 DIP	1.35	1.85	2.51	—
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new product at the Scottish Rite Memorial Temple, 6151 H St., opposite California State University in Sacramento.] **Contact:** Sacramento PC Users Group, P.O. Box 685, Citrus Heights, CA 95611, (916) 386-9865.

A Few Things That Bug Jean-Louis Gassée

Jean-Louis Gassée spoke to the Portland Macintosh Users Group this fall, and he spoke about the three things that bother him most: networks, databases, and programming.

Gassée began with networks, saying, "The good thing about standards is there are so many to choose from." He said the only universal network he knows of is the phone system, and that what the industry is missing is a network to be available "on tap." Gassée supports ISDN and suggested that everyone "band together to make it happen" in terms of networking. He noted that Europe and Japan were already installing ISDN, and "the Japanese are going to eat our sushi" if we don't get it together.

On mainframe databases and computers, Gassée said that the one great obstacle is the complexity of getting data out of the system. What's lacking is a way to make large sets of data available in a heuristic, not a predetermined, way. On mainframe databases, you can't stray from the programmer's predetermined path, which is not the future of computing, he said.

On programming, he said he considers programming languages the most interesting topic in computer science today, but that some of the new ideas, such as speech recognition, are flawed. He gave as an example speech impediments, like stuttering. Gassée said that for computers to achieve their full potential, programming facilities must improve.

Gassée also took questions from the floor. Here's a sample of what he said:

On a low-end machine running software for both the Apple II series and the Mac: "I think the answer is no. . . it doesn't work."

On the 90-day warranty: "Apple's position about the 90-day warranty is well known, and we get a lot of arrows in the back—or in the chest."

"Never start your kids with BASIC, it's bad for 'the brains.' "

"Programming should be a universal pursuit. How many own a VCR? How many like to program a VCR?"

"I don't want to yield to fashion and make the Macintosh as ugly as OS/2."—By Jane Dunkin, with additional quotes by Neil Wolf.

PMUG holds its general meetings on the second Monday of each month at the Northwest Service Center, 1819 Northwest Everett St., Portland, OR 97209. (For more information, see the January Pacific Regional What's New, page 96PC-2.) **Contact:** Portland Macintosh Users Group, P.O. Box 8949, Portland, OR 97207, (503) 228-1779.

It's not your 386 keeping the lid on productivity... It's your operating system.

It's taken a long time for the PC to be treated like a serious business machine. What it really needed to match mini-computer potential was the capacity to multitask, to handle more than one program at the same time. This flexibility would allow one user, or many, to dramatically increase productivity.

The hardware hurdle for PCs is history.

Thanks to the 386's true multitasking design, flexible and inexpensive mini-computer class PCs stand ready for power users and workgroup environments.

The last barrier has been an operating system advanced enough to truly implement the 386 design. Early multi-tasking attempts, and those based on the 8088, were forced to partition RAM to achieve basic multitasking.

It's a real waste.

Since most programs use a small fraction of the 640kb partition needed to accommodate them at any point in time, the remaining RAM was literally wasted. In addition, partitioning made program switching and protection a nightmare.

The operating system wait is over.

Vmos/3 is the first true 386 protected mode *virtual operating system kernel* for DOS. Not just a task switcher or DOS extender, Vmos/3 fully implements the 386 design.

Using demand paging, Vmos/3 allocates tiny 4kb memory units to programs *only when needed* from *any* available location in memory.

Furthermore, its virtual paging feature *swaps non-current pages to disk*, freeing even more memory resources.

The result is lean and mean.

These advances allow *effective* multi-tasking in 1mb machines. With more RAM, the performance curve zooms.

Consider the possibilities for memory and graphics intensive programs, like CAD, or limited resource machines, like laptops. Yes, Vmos/3 supports all video types & modes. Plus, *each* DOS Session sees a full 32mb of virtual LIM/EMS RAM for those programs that need expanded memory. Tasks run in Background and Foreground simultaneously, without program redrawing.

Why a DOS based system?

Estimates put the investment in DOS software at over $30,000,000,000. Business doesn't have time to trash budgets or productive hours to retrain on complex, variable standards or systems already made obsolete by the 386.

There's MultiUser, too.

Now, Vmos/3 has a partner, Vmos/MU. That same 1mb machine can provide an effective platform for a multiuser system where *each user* multitasks.

We're not kidding. Compare that ability to other multitasking systems limited by static memory partitions. The large RAM requirements and task limits per user reveal the real inefficiencies of partitions.

Advanced hardware opens the way.

Vmos/MU uses intelligent interface boards to reduce overhead, conserving CPU. Intelligent serial interface cards allow connection to inexpensive terminals. Alternatively, video extender interfaces let you use standard PC video monitors and keyboards for graphics intensive applications, each with the performance of a dedicated system.

Look out LANs, here we come.

These relatively inexpensive interfaces and peripherals, plus modest memory requirements, make Vmos/MU an extremely attractive alternative to LAN systems, without the LAN hassles and price tag.

With all this emphasis on value, what does Vmos/3 cost?

$199 for Vmos/3, with an introductory price of $99 more for Vmos/MU. Plus, we offer a 30 day money back guarantee, and free ongoing support. What a deal!

So, what's the catch?

1. No catch. We want to make it easy for you to buy Vmos/3.

2. We don't think you have to pay big bucks for us to make money. But it does help to have a great idea. Or, in our case, two or three.

3. Frankly, we want to knock the PC industry on its ear, and bring mini-computer performance to the 386 market at PC prices. The potential is enormous to bring powerful computing into every business, large and small. The way we see it, we've built a star ship.

Who is StarPath, anyway?

4. Our last reason for emphasizing value: We know we're new to you. (But not strangers to mainframe internals, or PC design.) In fact, our principals cut their teeth on front end communications and mainframes nearly twenty years ago. Now *there's* multitasking experience.

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Circle 502 on Reader Service Card (DEALERS: 503)

FormalSoft Ships 3-D Spreadsheet

ProQube, the successor to QubeCalc (FormalSoft's shareware program), provides 512 rows by 512 columns by 512 individual pages in its worksheet. The three-dimensional spreadsheet program lets you view your spreadsheet as if it were a cube, with the ability to rotate and slice across multiple sheets. You can view, enter, or manipulate data from multiple worksheets on the same screen.

ProQube's presentation-quality graphics let you generate three-axis bar and area charts with various fonts and colors. The program's application language lets you take advantage of windowing, menus, and error systems. It also offers DOS access. Application programs reside outside the worksheet, and you have the ability to set conditions to start up applications automatically. The spreadsheet can import and export Lotus 1-2-3 and dBASE files across multiple pages. Other features include search and replace, EGA 43-line support, and linking to other spreadsheets.

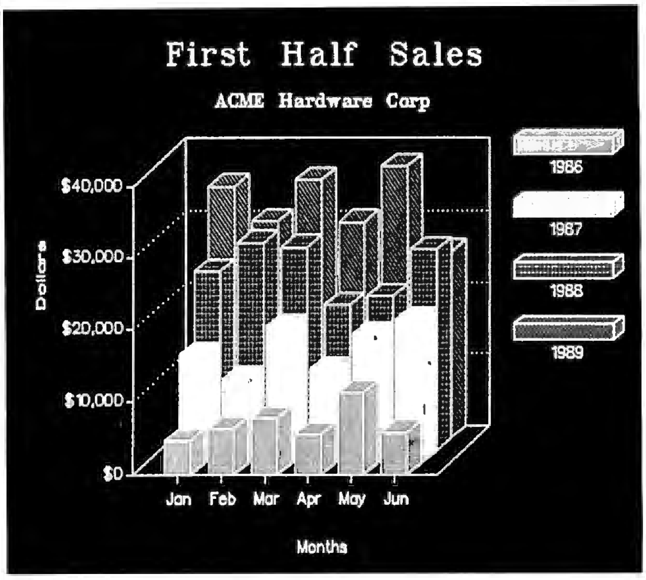
Novice users will appreciate the Back-Track menus that let you see each level of the menu system, a file manager, and a macro recorder.

ProQube runs on the IBM PC with 640K bytes of RAM, DOS 2.0 or higher, and a hard disk drive.

Price: $247.50.

Contact: FormalSoft, P.O. Box 1913, Sandy, UT 84091, (801) 565-0971.

Inquiry 1013.



ProQube's three-dimensional capabilities let you create three-axis bar graphs, like this comparison of four years' sales for a six-month period.

Storage Tank Inspections Made Easier

ChemCalc 17:EPA Storage Tank Emissions Analysis is a program for calculating organic liquid tank emissions of storage tanks in accordance with the recommended Environmental Protection Agency standards, Gulf Publishing reports.

All tank configurations found in EPA regulations are supported, as are all nine tank seals and painting combinations of roof and shell color; welded and riveted tanks; fixed, internal floating, and external floating tank roofs; tank diameter and height in feet; and more.

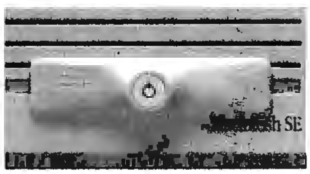
The program calculates the breathing and working losses for fixed-roof tanks and the rim seal and withdrawal losses for internal and external floating-roof tanks.

ChemCalc 17 runs on the IBM PC with 256K bytes of RAM.

Price: $495.

Contact: Gulf Publishing Co., Software Division, Dept. F6, P.O. Box 2608, Houston, TX 77252, (713) 520-4444.

Inquiry 1016.



Lock Your Macintosh with KeyLock

The first product from a company called VikingTech secures your Macintosh files with software for password protection and a physical lock for your floppy disk drive slot.

The password software of KeyLock is part of the INIT in the System file, and KeyLock rebuilds itself every time you log on, the company says. The KeyLock password prevents access to the hard disk drive.

Price: $89.95.

Contact: VikingTech, Inc., 5752 Oberlin Dr., Suite 200, San Diego, CA 92121, (800) 955-5625 or (619) 457-4935.

Inquiry 1014.

Ad-Composition Program Formats Text

With AdWorks 2.0, an ad-composition and full-page layout program for newspapers and ad departments, you can pour ASCII text into a template, and the program automatically converts it to the format in which it should appear. For example, if you must send the same ad to different newspapers, you can set the program up to format the text for each newspaper automatically. In addition to support for color, the program can search and replace for a font, style, point size, or color and replace one or all of them in the entire document or just an area that you specify.

You can scan a photo into the document for FPO purposes. Once in the document, you can crop, rotate, and reduce the photo or graphical image. Thus, when you send it to the printer, there won't be any doubt as to how the photo should appear. Text can flow around or inside irregularly shaped objects, Concept Publishing Systems reports.

AdWorks 2.0 features point-to-point kerning and tracking at up to 0.001 of an em space precision. Also new is an 85,000-word spelling checker. You can create grids and rulers in such increments as pixels, inches, picas, points, and millimeters.

AdWorks 2.0 runs on the Macintosh Plus or higher with 1 megabyte of RAM, but the company recommends that you have at least 2 megabytes.

Price: $1495.

Contact: Concept Publishing Systems, 809 Park Ave., Beaver Dam, WI 53916, (414) 887-3731.

Inquiry 1012.

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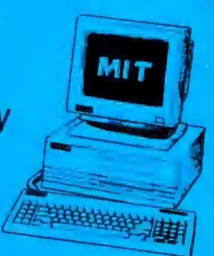

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UltraDrive Your Mac Without Frills

GCC Technologies' UltraDrive series for the Macintosh offers no-frills hard disk drives with 20- to 80-megabyte capacities.

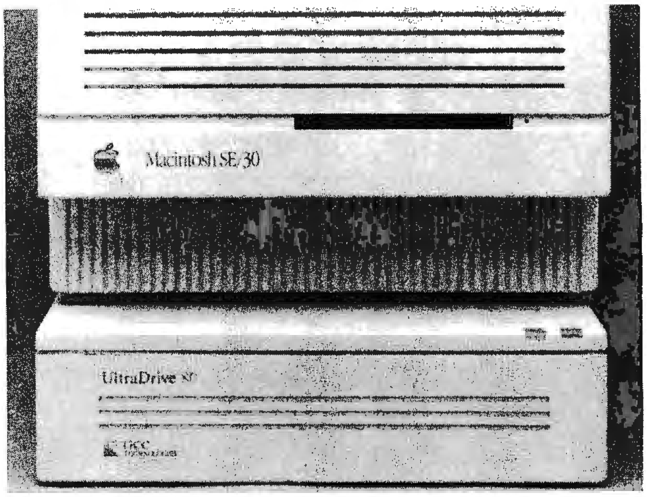
The drives are available in standard internal configurations and in unconventional "zero-footprint" configurations to fit directly beneath a Mac Plus, SE, or SE/30. They measure 3 by 10 by 11 inches.

Every UltraDrive includes software for installation, partitioning, securing partitions (through passwords), and testing.

Price: 20-megabyte external, $549; 30-megabyte internal and external, $529 and $629; 45-megabyte, $599 and $699; 80-megabyte, $849 and $949.

Contact: GCC Technologies, 580 Winter St., Waltham, MA 02154, (617) 890-0880.

Inquiry 1000.



When GCC says that its UltraDrive has a "zero footprint," the company means that it fits under your Macintosh.

Intex Upgrades Trans, PanaView for Lotus 1-2-3

Intex recently upgraded Trans and PanaView, two Lotus 1-2-3 and Symphony add-on products. Trans, which integrates ASCII data into Lotus spreadsheets, has two new command-line options in version 1.04. The first one eliminates multiple copies of page headings in the worksheet file that Trans creates, and the second option cuts the memory required to run the product by matching the minimum number of lines to the column structure in the source file.

PanaView lets you manage large spreadsheets by being able to view up to 43,000 cells on a screen. You can use a zoom window for a close-up look. PanaView 1.1 flags blank formatted cells, so you can find and fix them. The program highlights unprotected ranges and adds more colors to the screen to help you distinguish among formulas, values, and text.

Trans 1.04 works with Lotus 1-2-3 up to release 3.0. PanaView works with release 2.2; a version for release 3.0 is expected by the end of this year, the company reports.

Price: Trans, $95; PanaView, $145.

Contact: Intex Solutions, Inc., 161 Highland Ave., Needham, MA 02194, (617) 449-6222.

Inquiry 1001.

Do-It-Yourself Calculator for the Mac

Calculator Construction Set (CCS) 2.0 lets you build a calculator as simple as a basic adding machine or one complex enough to handle your financial and scientific problems in a MacPaint-like environment on the Macintosh.

You start with a basic calculator window, drag tools onto it, and assign functions to the tools. A key can be a number or any of 245 functions for statistics, math, or trigonometry. Once you have the calculator the way you want it, you can save it as a standalone application, desk accessory, or work file. Finished calculators can run in standard algebraic or reverse Polish notation.

The program can cut, copy, and paste data between the calculator and applications. An on-screen "paper-tape" display can hold up to 32K bytes of text, and you can edit this by clicking on the tape. Displays can show up to 24 characters.

The program comes with 61 ready-to-use calculators and 10 template files. Developer Dubl-Click reports that the program will run most HP-41C calculator programs, and it runs on systems as basic as the original 128K-byte Mac.

Price: $89.95.

Contact: Dubl-Click Software, Inc., 9316 Deering Ave., Chatsworth, CA 91311, (818) 700-9525.

Inquiry 1003.

View AutoCAD Drawings Without AutoCAD

Not everyone who needs to view an AutoCAD drawing needs to be a CAD user. A program called Viewstation from Sirlin Computer lets you view, rotate, print, zoom, and even add a personal note to an AutoCAD drawing on a standard IBM PC without requiring you to have AutoCAD on the system. The program will read AutoCAD drawing files directly, including release 10 drawings, in a read-only format.

Viewstation can zoom drawings, turn layers on and off, and restore named views. The company reports that the program draws up to 10 times faster than AutoCAD.

Since the program treats AutoCAD files as read-only files, you can use it to archive drawings on a WORM (write once, read many times) drive, a CD-ROM drive, or a network server. The program's Hyper-Link capability lets you tie sets of drawings together. You can look at a map of a region, for example, point to the region, and load a detail of a particular subdivision of the region onto your screen.

Viewstation runs on the IBM PC with 512K bytes of RAM. A coprocessor is optional. Sirlin reports that next year it will release database drivers for the program, letting you use it as a graphical front end for database systems.

Price: $295.

Contact: Sirlin Computer Corp., 225 Lowell Rd., Hudson, NH 03051, (603) 595-0420.

Inquiry 1002.

Do You Know Someone Who'd Like a Career in Technology?

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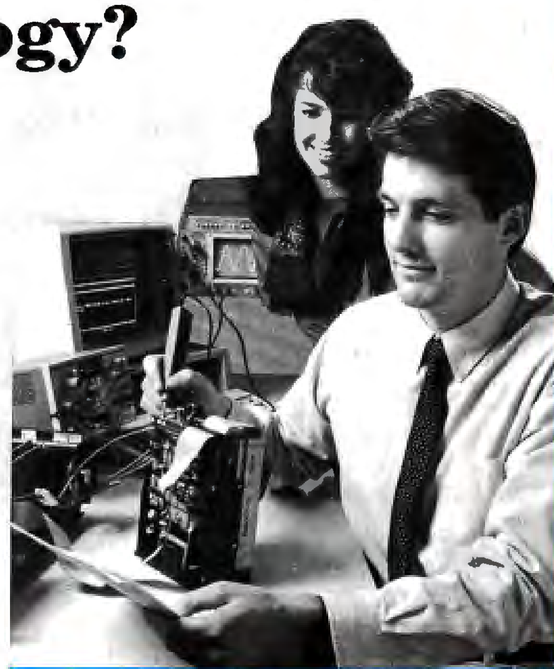

We've been training men and women for technical careers for over 125 years. Our graduates begin as electronics or computer service technicians—and many go on to supervisory positions. We're a nonprofit college with an emphasis on modern equipment and excellent, personalized teaching *and we place over 95% of our graduates.* Heald's 18 month program leads to an AA Degree in Electronics Technology and day or evening classes are available. If you're working with or know someone who is ready to move ahead in technology, a word about Heald could well be the one favor he or she will never forget.

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Computers For The Blind

Talking computers give blind and visually impaired people access to electronic information. The question is how and how much?

The answers can be found in "The Second Beginner's Guide to Personal Computers for the Blind and Visually Impaired" published by the National Braille Press. This comprehensive book contains a Buyer's Guide to talking microcomputers and large print display processors. More importantly it includes reviews, written by blind users, of software that works with speech.

This invaluable resource book offers details on training programs in computer applications for the blind, and other useful information on how to buy and use special equipment.

Send orders to:
National Braille Press Inc.
88 St. Stephen Street
Boston, MA 02115
(617) 266-6160

$12.95 for braille or cassette, $14.95 for print. ($3 extra for UPS shipping)
NBP is a nonprofit braille printing and publishing house.

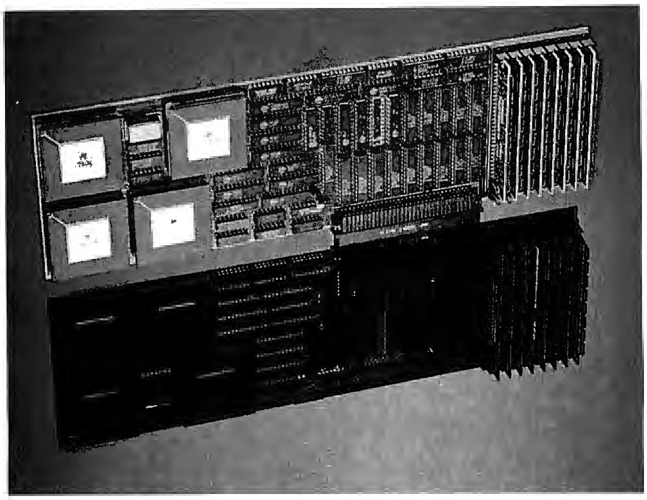
Mac II Coprocessor Uses 88000 RISC Architecture

Software applications on a Macintosh II with the new Tektronix RP88 graphics coprocessor board will operate up to 30 times faster than on a 68020-based Mac II, Tektronix claims. That's because the RP88 has a Motorola 88000 RISC processor as its engine.

The RP88 also contains a 20-MHz 88100, 2 megabytes of DRAM, a 32K-byte cache, and a built-in floating-point coprocessor, resulting in a claimed rating of 17 million instructions per second.

Applications that take advantage of the coprocessor will split duties between it and the native 68020. Access to the screen, keyboard, disk, and user interface is managed by the 68020 to take advantage of the Mac OS and Toolbox. Computationally intensive math and graphics are shifted to the 88100.

Price: RP88, $9575; developer's kits for C and FORTRAN, $995 and $1995, respectively.
Contact: Tektronix, Inc., Tektronix Industrial Park, P.O. Box 500, Beaverton, OR 97077, (503) 627-7111.
Inquiry 1004.



The RP88 coprocessor board provides up to 17 million instructions per second.

Two Programs for the Legal Profession

Client Management and Docket Control from LegalBYTES lets you customize its rules of procedure to fit your requirements. Once you've defined your rules, CMDC will recommend dates (e.g., a statute of limitations) by which you should accomplish a task.

With CMDC, you can manage an unlimited number of clients and matters per client, court appearance dates, and other deadlines. It has an opposing counsel database, and you can view dockets in several ways through Agenda-like views. A utility lets you transfer names and addresses from Timeslips, North Edge Software's time and billing program. CMDC can also import data in fixed and comma-delimited ASCII format. CMDC works on the IBM PC with 512K bytes of RAM and a hard disk drive.

Price: $299.
Contact: LegalBYTES, Inc., 9700 Richmond Ave., Suite 230, Houston, TX 77042, (713) 787-0090.
Inquiry 1006.

TSC Computing recently released PC Constitution 1.0, a database of the U.S. Constitution. The database includes the Bill of Rights and all amendments. Using Supra II (a substantive system that lets you assemble documents by searching for and retrieving essential text) and PC Constitution, you can quickly assemble legal documents and briefs to retrieve information in a HyperCard-like fashion and assemble sections of text into a complete document.

Browsing, pasting, printing, and word searches are possible with pull-down and pop-up menus. The program runs on the IBM PC with 256K bytes of RAM. The Plus Edition has indexed word-search capabilities, TSC Computing reports.

Price: Standard Edition, $24.95; Plus Edition, $49.95.
Contact: TSC Computing, Inc., P.O. Box 872687, Wasilla, AK 99687, (907) 373-6550.
Inquiry 1007.

Modify Text in HyperCard Stacks Sans HyperCard

Symmetry's HyperDA, the HyperCard stack browser, now lets you modify text fields in HyperCard stacks without requiring HyperCard itself. With HyperDA 1.2, you can search and retrieve HyperCard stacks, modify the text, and save it to disk.

You can also use HyperDA 1.2 to put HyperCard stacks on a Macintosh with as little as 512K bytes, because the program needs only about 67K bytes.

Symmetry reports that it has also added an auto-open feature and enhanced the Find function.

Price: $89.
Contact: Symmetry Corp., 225 East First St., Suite 107B, Mesa, AZ 85201, (800) 624-2485 or (602) 844-2199.
Inquiry 1005.

Nutrition Planner Helps You Eat Healthier

The Nutrition Prospector is for professional dietitians, nutritionists, and health-conscious consumers who want to analyze and improve diets.

The program's database is derived from the USDA's *Agriculture Handbook 8* and some of its supplements. The database has more than 2500 entries, and you can add more. The program tracks basic nutrient variables such as fat, protein, cholesterol, sodium, calcium, and fiber.

Nutrition Prospector lets you enter in a recommended diet. You can compare foods actually eaten to recommended foods and see the effects of the substitution on nutrient values, totals, and goals on a per food, meal, or daily basis. You can also produce summary reports for one or several days.

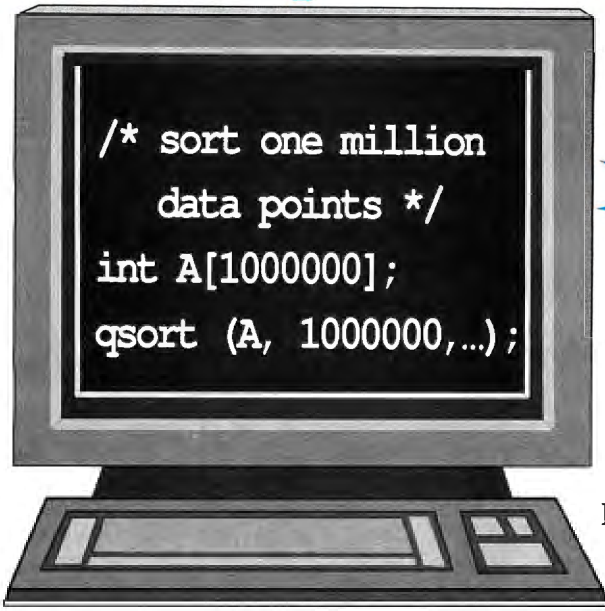
The program comes in two versions. With the Professional version, you can track and maintain client and organization information. The Personal version lets you track all the members of your family.

Both versions run on the IBM PC with 640K bytes of RAM, DOS 2.1 or higher, and a hard disk drive.

Price: Personal version, $79; Professional version, $185.
Contact: Constructive Solutions, Inc., 5506 Mercedes, Dallas, TX 75206, (214) 826-4327.
Inquiry 1008.

MS-DOS 386•486

Can your C compiler handle this?



MetaWare's High C ® and Professional Pascal ™ — the *first* C and Pascal compilers to generate 386 protected-mode code for MS-DOS. And the compilers themselves can run in protected mode, giving you the power to create large programs.

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- ***Fox Software – FoxBase+/386***
- ***IBM – Interleaf Publisher***
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** MIPS magazine, October, 1989. See articles on 80486, YARC 29000, and 386 Great Performers.*

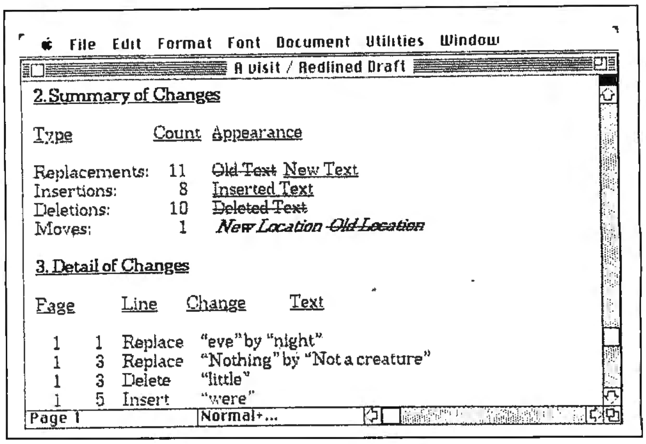
Document-Comparison Program

DocuComp, a document-comparison program for the Macintosh and the IBM PC, can directly compare files from two different word processors in their native file formats and save them in a third format, while preserving 99 percent of the character formatting, the developer reports.

According to Advanced Software, DocuComp converts the word processor's format into its own format and then converts it back to the original (or a different) format, while comparing the versions of the document or program. A mode for programmers shows changes made in source code listings. The new version shows changes in documents that are periodically updated, but it can also serve as a word processor file conversion program.

DocuComp presents the results of the comparison in three ways. A two-panel comparison window shows corresponding sections of the compared documents, in which you scroll both documents in sync or jump to the next or previous change. Each change is highlighted. In another form of display, a saved or printed document shows inserted, deleted, replaced, and moved text. The program identifies changes within moved text. And finally, a comparison summary gives you each revision made by page and line number.

DocuComp 1.0 deals mostly with the words, ignoring character attributes such as boldfacing, underlining, and changes in fonts. Version 2.0 for the IBM PC should be available by the time you read this; the upgrade for the Mac should be available in January, the company reports.



DocuComp shows you precisely the changes in your document.

The program requires at least 384K bytes of RAM in its IBM PC and Mac versions.
Price: $159.95.
Contact: Advanced Software, Inc., 1095 East Duane Ave., Suite 212, Sunnyvale, CA 94086, (408) 733-0745.
Inquiry 1009.

Develop Systems at the Design Level

Applaud lets you develop and maintain multiuser IBM PC–based systems at the design level without writing one line of programming code, according to International Consulting Enterprises (ICE). Once you've finished designing the application, Applaud will analyze the design specifications and produce a customized user's manual. You can customize the manual for individual users, so that only the features they are permitted to access are documented. The manual includes a data dictionary, database specifications, application specifications, and a system cross-reference list.

Applaud uses a building-block technique. Components include a screen generator, a screen painter, five report generators, and import/export functions. When you develop a system, windowing technology, bar menus, password security, and context-sensitive help are automatically included.

ICE reports that Applaud works with any CASE methodology, or no methodology at all. Applaud analyzes the design specifications and performs record locking and file locking as required by a network. Applaud is written in Realia COBOL and runs on the IBM PC with DOS 3.0 or higher, 640K bytes of RAM (485K bytes free), and 3 megabytes of memory on a hard disk drive.
Price: $2495.
Contact: International Consulting Enterprises Ltd., 10 South Riverside Plaza, Chicago, IL 60606, (800) 426-0428 or (312) 454-3200.
Inquiry 1010.

Mac Printing on HP Laser Printers

The Grappler LX is an inexpensive printer interface for HP-compatible laser printers, DeskJet printers, and Epson 24-pin printers that works with your Macintosh Plus, SE, SE/30, II, IIx, or IIcx.

It includes AppleTalk compatibility and five fonts (Swiss, Courier, Dutch, Garamond, and Zapf Chancery Medium Italic). For quick installation, you use the Auto-Installer software.
Price: $199.
Contact: Orange Micro, Inc., 1400 North Lakeview Ave., Anaheim, CA 92807, (800) 223-8029 or (714) 779-2772.
Inquiry 1011.

Business Calculator for Maximizer

Richmond Software has introduced an add-on business calculator for the company's contact-management program, Maximizer. With MaxCalc, all calculations are visible on a scrollable tape, and you can insert them into a note or diary entry in Maximizer or paste them into a letter using Maximizer's cut-and-paste routine.

Two modes, standard and reverse Polish notation, are available. The calculator can handle discounted cash flow analysis, annuities, actuarial, depreciation, bonds, simple and compound interest, loan amortization, statistics, and interest rate conversion.

Maximizer itself can handle writing, note taking, diary entries, expense accounts, and label printing. Maximizer runs on the IBM PC with 640K bytes of RAM and a hard disk drive.
Price: $24.95; Maximizer, $195; Maximizer for LANs, $495.
Contact: Richmond Software, Inc., 6400 Roberts St., Suite 420, Burnaby, BC, Canada V5G 4C9, (604) 299-2121.
Inquiry 1015.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* 7.2 Mhz AXT Main Bd 5 Yr Mfg Warranty C1
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* Case /150 W Power Supply
* Hires amber monitor
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* Enhanced AT style keyboard

For The Student $549

CDS 286 Model 12

This AT system features great performance at a low price with a 12 Mhz 0 wait memory wait state memory access with up to 4 MB of on board memory gives you uncompromised AT features and speed. Choice of Std AT case or newMini Tower are included in this special offer:

* 12 Mhz Main Board w/ 640 KB Memory C3
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* HD/FD Controller
* Std AT or Mini tower Case w/ 200 W PS
* Hires amber monitor
* Graphics controller with printer port
* Enhanced AT style keyboard

$ 779

CDS 286 Model 16

If a simple high performance 80286 is what you need this system delivers with 21.7 Mhz AT equivalent speed and SI of 18. Options include 80287 math co-pro and up to 4 Mb memory.

* 16 Mhz Main board w/1 MB Memory C4
* 1.2 MB Floppy Disk
* 1:1 HD / FD Controller
* Std AT or Mini tower Case w/ 200 W PS
* Hires amber monitor
* Graphics controller with printer port
* Enhanced AT style keyboard

$899

CDS 386 SX Model 20

If 20 Mhz AT Performance is what you need consider this system and unlock increased 386 software capabilities and improved memory management. This system is based on a US manufactured main board running at 16 or 20 Mhz. The system includes:

* 16/20 Mhz 80386SX Main Board C7
* 1 MB Memory
* 1.2 MB Floppy Disk
* Std AT or Mini tower Case w/ 200 W PS
* 1:1 Hard / Floppy Disk Controller
* Hires amber monitor
* Graphics controller with printer port
* Enhanced AT style keyboard

$ 1129

CDS 386 Model 20

This 20 Mhz system is a excellent entry level 80386 main board. This system uses a US Manufactured board. Memory option bds include a 1 or 2 MB bd and a 4 or 8MB board. The system includes:

* 20 Mhz 80386 Main Board w/1 MB Memory
* 1.2 MB Floppy Disk
* 1:1 Hard / Floppy Disk Controller
* Std AT or Mini tower case w/ 200 W PS
* Hires amber monitor
* Graphics controller with printer port
* Enhanced AT style keyboard

$ 1499

CDS 386 Model 25

This 25 Mhz system is a great 386 value using the Chips and Tech chip set. It is 100%80386 Software compatable and provides up to 24 MB of O/S 2 compatible memory. Options include a full size bd in a full tower case w/ 230 watt PS; 80287 or 80387 co-processors; 32 bit memory bd. The system includes:

* 25 Mhz 80386 Main Board w/ 1 MB Memory C8
* 1.2 MB Floppy Disk
* 1:1 Hard / Floppy Disk controller
* Mini tower Case / 200 W PS
* Hires amber monitor
* Graphics controller with printer port
* AT style keyboard

$ 1549

CDS 386 Model 25 - 64K

This 25 Mhz system uses the fastest 25Mhz 80386 main board. This system has a standard 64K memory cache with an optional 256K cache for those applications better suited to the larger cache memory. Effective cache management is the key to high AT speed equivalent of 43.5 Mhz. The system includes:

* 25 Mhz 80386 Main Board w/1 MB Memory C9
* 1.2 MB Floppy Disk 256K Cache Add $389
* 1:1 Hard / Floppy Disk Controller
* Full tower Case / 230 W PS
* Hires amber monitor
* Graphics controller with printer port
* AT style keyboard

$ 1989

CDS 386 Model 33 - 64K

The fastest 33Mhz 80386 System Uses a standard 64K memory cache with an optional 256K cache . AT Speed Equivalent of 58.5 Mhz is the fastest desk top AT type computer. The system includes:

* 33 Mhz 80386 Main Board w/1 MB Memory C10
* 1.2 MB Floppy Disk
* 1:1 Hard / Floppy Disk Controller
* Full tower Case / 230 W PS
* Hires amber monitor
* Graphics controller with printer port
* AT style keyboard

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System Add-on w/System Purchase:

360K 5¼" Fujitsu or Chinon....$ 68	20 MB HD 28 ms..........$ 229	14" Amber Flat Screen Mon...$ 39	VGA Cntr (1024x768) 16 bit.....$ 399
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720K 3½"..................$ 78	30 MB HD 28 ms..........$ 259	14" EGA Mon w/cntr.........$ 329	Modems, 2400 Baud, Ext. Frm...$ 119
1.44MB 3½"................$ 88	40 MB HD 40 ms..........$ 309	14" VGA Mon w/16 bit cntr....$ 399	AT IO Card, Ser, Par & Game...$ 39
20 MB HD 65 ms acc.........$ 199	40 MB HD 28 ms..........$ 339	19" VGA M1024 x 768 w/cntr..$ 1499	Dot Matrix Printer.......From $ 145
	66 to 330 MB HD from.......$ 399	VGA Multiscan w/cr(800 x 600).$ 499	PC Mouse...............From $ 48

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AT Solutions (Columns 3 & 4) Replace your slower AT mother bd with out 12 Mhz Baby AT (fits original AT) for only...$229! This board runs as fast as a 15.6 Mhz AT & a Norton SI or 15.2 with existing 120 ns memory. Get the 16 Mhz version for $289.

Bridge 286-12(Column 5) This board is comparable to Transformer Bd with a on board four floppy controller and brings full AT 12 Mhz performa to your PC or XT slot or 8 Slot. It provides full OS/2 capability with up to 6 MB of on board memory Board with 0 K **$ 495** With 1 MB **$ 649**

Compaq Portable Solution (Column 5) The Bridge 286/CP is the ideal Upgrade fo that trusty Compaq. 12 Mhz zero memory wait state performance with up to 6 MB o on board memory and 100% Compatablity makes this a winner. Board w/0k **$ 495**

80386SX Upgrade Solutions (Columns 6 & 7) Why settle for 20 Mhz 80286 performance when you can have a 16 or 20 Mhz 80386SX with all the performance benefits of running 386 software and memory management! From $399.

80386 Solutions 80386 Upgrade with Baby sized or full size 386 is your solid, reliabl 386 solution. Based on the Chips and Tech chip set This Board is available in eithe baby or Full size. Special offer. 24 Mhz 386 Board w/1meg **$ 999**

80386 Cache 25 Mhz and 33 Mhz Now you can upgrade to the highest 386 perfor mance with solid Made in US mother boards. These bds feature std 64 KB cache (Bes way to get close to Zero Wait State Performaance with Drams.)

25 Mhz from $ 1499 and 33 Mhz from $ 2499 Limited time offer.

Column	1 Bullet 286 286-7.2	2 2Bullet 286 286-10 / 286-12.5	3 Precision AT 286-12	4 Precision AT 286-16	5 Bridge 286 286-12	6 Precision 386SX 80386-16SX (P9)	7 CCI 386SX 386SX-16/20	8 Precision 386 386-24	9 80386- C64 386-25	10 80386-C64 386-33
CPU	80286-8	80286-8 / 10/12	80286-12	80286-16	80286-12	80386SX-16	80386SX-16	80386-20/25	80386-25	80386-33
Math Co-po	80287-2/3	80287	80287	80287	80287	80387SX	80387SX	80287/80387	80387	80387-33
Cache Ram	N	N	N	N	N	N	N	N	64K/256K	64K/256
Dram Type	64/256K	64/256K	64/256/1024K	64/256/1024K	256k/1M SIMMS	256k/1M SIM	256/1M SIM	256/1M SIP	256/1M SIM	256/1M SIM
Mem Speed	150ns	120 / 100ns	120/100 ns	80 ns	100ns	100ns	100 ns	100/80 ns	100/80 ns	80 ns
Mem Config	512/640K/1M	512/640K/1M	512/640K/1/2/4M	512/640K/1/2/4M	512K/1M to 6M	512/640k/1/2/4MB	512K to 8MB	1/2/4/8/16MB	1/2/4/8/16MB	1/2/4/8/16MB
8 Bit Slots	8	8	2	2	(2) 5	2	2	1	2	1
16 Bit Slots	0	0	6	6	(3) 3	6	6	4 + 2 Ser/ 1 Par	5	5
32 Bit Slots	0	0	0	0	0	0	0	1	1	1
BIOS	Quadtel	Quadtel	Award /AMI	Award /AMI	Phoenix	Award	Phoenix	AMI	AMI	Phoenix/AMI
Relative Speed	9	12.4 / 15.6	15.6	21.6	15.4	20.1	18.0/21.4	32.6(2 banks)	40.2/43.8	58.7
SI Rating	8.2	11.0 / 14.7	13.7	18.3	15.2	17.6	17.2	29.7	31.6	40
Price w/o Mem	$ 149	$ 199 / $ 219	$ 209	$ 289	$ 495	$ 399	$ 599	$ 749	$ 1449	$ 2499
Price w/1MB	$ 249	$ 349	$ 329	$ 349	$ 609	$ 579	$ 729	$ 919	$ 1629	$ 2689

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Circle 494 on Reader Service Card

BYTE editors' hands-on views of new and developing products

A Macintosh-Compatible Laptop from Wallaby

What do you get when you cross a **Wallaby** with a Macintosh? You get your old Mac Plus or SE without the ROMs (bootable by the Wallaby), and you also get a 15-MHz Mac-compatible laptop that weighs 10 pounds.

We were a little skeptical at first. But when we got our hands on a prerelease Wallaby and ran it through the BYTE benchmarks, we found that it is actually a bit faster than the Mac Portable and about twice as fast as a stock Mac SE. The Wallaby ran all our major well-behaved software (e.g., MacWrite II and Excel 2.2) without complaint.

The system looks like an ordinary laptop at first glance, but it's actually a Mac peripheral in function. When you get the system, you have to take your Mac to a dealer to have the ROM chips removed and then installed in the Wallaby. When you want to boot your Mac, you have to connect the Wallaby to it with a host connector cable. This gives your Mac access to the Wallaby's 15-MHz CPU, 1 to 4 megabytes of system RAM, floppy disk drive, screen, and optional silicon disk.

The internal floppy disk drive can read and write both Mac-formatted 800K-byte floppy disks and IBM-formatted 720K-byte floppy disks. The screen, which can function as a second screen for your Mac, is a backlit, black-on-white 640- by 400-pixel LCD. You configure and operate the Wallaby screen via a control panel on-screen. You can put the same document on both screens, a menu on one and a document on the other, or have one window spread over both screens.

Besides the 1 to 4 megabytes of RAM, you can add up to 16 megabytes on the silicon disk. Wallaby Systems claims that the disk operates for up to a month between battery recharges. The disk appears as a logical hard disk drive icon on the Desktop, and you can also boot the system from the silicon disk.

The rechargeable battery that comes with the Wallaby will stay fully charged for about 3 hours. A wall-mount transformer comes with it for recharging. The sealed battery flips out of the screen's back to serve as a stand and as support for the screen.

The design takes some getting used to. When we first saw it, we couldn't figure out how the screen flipped up. And using the battery as a support seemed very awkward.

The Wallaby's wireless infrared keyboard has a Mac SE layout and a built-in Isopoint pointing device. The Isopoint is pencil-shaped, and you roll it up or down, left or right, to move the cursor in those directions. Typing was pleasant using the keyboard of the preproduction unit we evaluated, even with the presence of the Isopoint, which is really a mouse-replacement device. We obtained the best results by using our thumbs to control the Isopoint, but index fingers would work as well. You can use an optional mouse, which you plug into the wireless keyboard.

The Wallaby comes with a host adapter/expansion port, an AppleTalk-compatible printer port, a communications port, and an external LCD port. A SCSI adapter cable is available as an option.

While a formal evaluation must await the final product, we think the Wallaby/Mac combination makes a powerful duo. It provides an interesting upgrade path for current Mac Plus and SE owners, who gain the functionality of a portable Mac with double the clock speed, a second screen, and IBM PC read/write capability. At roughly half the price of the Mac Portable, the Wallaby may be a serious alternative. □

—Anne Fischer Lent and Laurence H. Loeb

THE FACTS

Wallaby
Base system, $2995; with 1.44-megabyte floppy disk drive, $3095; with 20-megabyte hard disk drive instead of a floppy disk drive, $3995.

Options:
Mouse, $95; SCSI adapter cable, $95; spare battery, $95.

Dimensions:
12⅓ by 7⅘ by 3⅗ inches; weight: 9¾ pounds (including battery and hard disk drive).

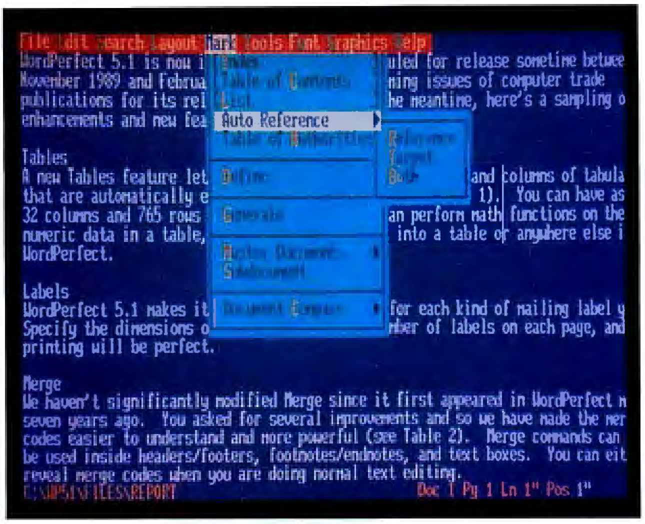
Wallaby Systems, Inc.
2540 Frontier Ave.
Boulder, CO 80301
(303) 444-4606
Inquiry 981.

continued

Mouse-ified and Feature-Laden

In the past, WordPerfect was one of the few programs that resisted the Macintosh-like simplicity of mice and menus. But that's about to change. **WordPerfect 5.1** will support a mouse and pull-down menus. And eventually—in version 6—the program will support a full graphical user interface. In the meantime, the ease-of-use features shouldn't get in the way of experienced WordPerfect users.

I saw a beta copy of WordPerfect 5.1, which included a spreadsheet-like tables feature, designed to simplify creating boxed tables in a document; an equation editor, for creating mathematical equations; "hot links," for including spreadsheet data or graphics in a document without actually copying the data or graphics into the document file; and the ability to print the hundreds of characters that become visible on-screen with WordPerfect 5.0. Version 5.1 also includes such improvements as dictionary-based hyphenation, better context-sensitive help, and improved merge, tabs, outlining, and justification.



THE FACTS

WordPerfect 5.1 $495 *Requirements:* IBM PC or compatible with 384K bytes of free RAM.	WordPerfect Corp. 1555 North Technology Way Orem, UT 84057 (801) 222-5600 **Inquiry 982.**

I don't know how snappy the performance on WordPerfect 5.1 will be, but I suspect it will be similar to that of version 5.0. Also, WordPerfect Corp. has guaranteed that version 5.1 will still run in well under 640K bytes of RAM.

While some may find fault with the large number of features in the new WordPerfect, I found that those you don't need don't seem to get in the way, and features you need are likely to be there. As long as the program will run on desktop computers that don't have expanded or extended memory, I agree with the company's philosophy: the more features, the better.

But with so many features, the new versions of WordPerfect are intimidating to new users, and even experienced users may have trouble figuring out how to get at features they don't often use. That's why I'm glad to see the improved help and the pull-down menus. The menus will help get new users up to speed, and experienced users can turn them off.

WordPerfect Corp. claims it currently holds 60 percent of the word processing market, and its goal is to make WordPerfect the word processor for everyone. I'm not sure that's possible; it smacks of the hubris that once plagued integrated software, which tried to do everything and ended up doing nothing well. WordPerfect 5.1's equation editor, for example, is usable, but I wouldn't want to write a calculus textbook with it. And the hot links for graphics and spreadsheet data are fine, but not as flexible as a true object-oriented system.

This new version of WordPerfect has avoided the bloating that has afflicted the new versions of Lotus 1-2-3 and dBASE. It still fits into an ordinary IBM PC's memory—and runs on an ordinary PC's CPU. As long as WordPerfect continues to work on almost every PC clone ever made and includes almost every feature its users have ever asked for, I don't think the company will go too far wrong. □

—***Frank Hayes***

Easygoing 2-D CAD on the Macintosh

As the name suggests, **Vellum**, which is a two-dimensional CAD program for the Macintosh, is designed to act as a fine sheet of drawing paper.

The screen is standard Mac (i.e., pull-down menus and icon palettes). When you position the cursor over an icon, the upper left corner of the screen explains what the icon does. To draw an entity, you select from the icon palette, position the mouse, and click. A ghost shape will rubber-band and follow the mouse around the screen. Most functions work in this way. Point, click, and drag is the essential operation in any Vellum function. A limited gesture-recognition ability lets you zoom in and out of your drawing without going back to the menus.

Perhaps Vellum's most striking feature is the Drafting Assistant. This drawing aid lets you accurately place objects in relation to one another. As the cursor moves across the screen, Vellum compares the cursor to every other object, looking at endpoints, midpoints, and intersections. If the cursor matches any of these points, Drafting Assistant locks to it, labels it, and shows you a temporary construction line. Getting objects to line up perfectly is a snap.

Vellum's feature list is on a par with those of other mainstream CAD products. Scaling, rotating, layers, dimensioning—they're all included with the standard package. I compared Vellum side-by-side with Claris CAD and AutoCAD for the Mac to get a feel for the differences.

Claris CAD felt a lot like MacDraw. It didn't seem as if I had as precise control over objects as I had with Vellum. The icons were not always intuitive and didn't have the self-explanation feature. Compared to Vellum, Claris CAD had a wimpy feeling.

AutoCAD is perhaps more powerful than Vellum, but it's also much more complicated. I have used AutoCAD before on the IBM PC, and I've never liked it. Vellum gives you the same level of control over

continued

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- You can easily write assembly language routines that call C functions and vice versa, because the compiler uses simple, well documented parameter passing conventions.

2. ASSEMBLER: CrossCode C comes with a Motorola-style assembler that has all the features that assembly language programmers require. In fact, you could write your whole application with it:

- The assembler features an advanced macro language, conditional assembly, "include" files, and an unlimited size symbol table.
- Detailed cross references show you where you've defined and referenced your symbols.
- After a link, you can actually convert your "relocatable" assembler listings into "absolute" listings that contain absolute addresses and fully linked object code.

3. LINKER: The **CrossCode** C linker is designed to handle truly huge loads. There are no limits on the number of symbols in your load or on the size of your output file. And you can always count on full 32 bit target addressability, because the linker operates comfortably in the highest ranges of the 68030's address space.

4. DOWNLOADER: CrossCode C comes with a *downloader* that puts you in touch with all EPROM programmers and emulators. It can convert your load into Motorola S-Records, Intel Hex, Tek Hex, Extended Tek Hex, and Data I/O ASCII Hex. You can also produce a binary image and convert that image into any format you might want. In all formats, bytes can be split into EPROMs for an 8, 16, or 32 bit data bus.

Why Wait

Once you start using **CrossCode** C, you may just wonder how you ever got the job done before! It's available under MS-DOS for just $1595, and it runs on all IBM PCs and compatibles (640K memory and hard disk are required). Also available under UNIX, XENIX, and VMS.

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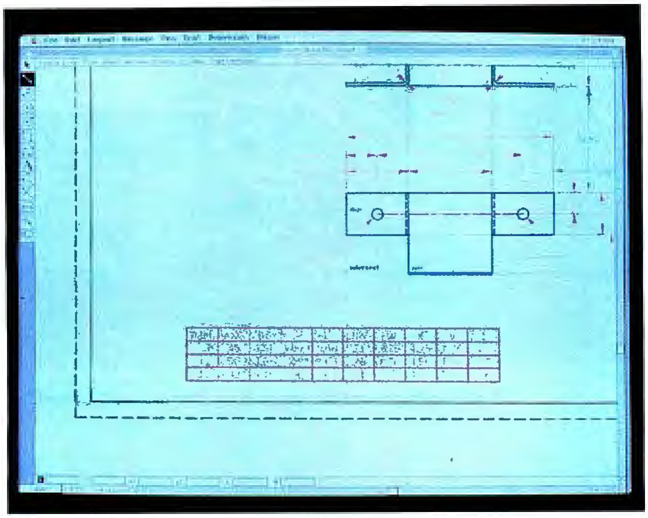
SOFTWARE DEVELOPMENT SYSTEMS, INC.
DEPARTMENT 22
4248 BELLE AIRE LANE
DOWNERS GROVE, ILLINOIS 60515 USA

THE FACTS

Vellum
$995

Requirements:
Mac II or SE with 4 megabytes of RAM, a hard disk drive, and preferably a large color monitor.

Ashlar, Inc.
1290 Oakmead Pkwy.,
Suite 218
Sunnyvale, CA 94086
(408) 746-3900
Inquiry 983.



objects while retaining its "Macness." Of course, AutoCAD gives you three-dimensional modeling. Ashlar has announced its three-dimensional add-on, which was not included with the beta version I tested.

The base price is expected to be $995, which includes all the features I've mentioned, plus associative detail views, NURB splines, parametrics, symbol libraries, and many others. Hard copy comes from the standard Mac printing devices or a pen plotter. Plotter drivers should be included in the shipping product.

Unfortunately, this power requires a Mac II or SE/30 with at least 4 megabytes of RAM, as well as the biggest monitor you can scare up. Color is definitely recommended. As for speed, I ran our beta copy on both a Mac IIcx and a standard Mac II, both with 4 megabytes. Vellum was fine on the Mac IIcx, but a bit poky on the Mac II. Ashlar expects to improve the speed by Vellum's release date.

Vellum combines big features, a small price tag, and a terrific interface. It's a package worth looking at if you're serious about CAD. □

—Howard Eglowstein

The Stationary Mouse

Logitech's new input device, the **TrackMan Stationary Mouse**, consists of a rectangular pad with a thumb-operated trackball in the lower left corner and three selection buttons in the upper right area of the pad. Measuring 4 by 3 inches, the pad supports the palm of your hand. You rotate the trackball with your thumb, which moves the cursor or pointer on the screen, and you click the selection buttons with your fingers. You don't need to move your hand or the TrackMan to perform this operation.

TrackMan is an optomechanical device with a default resolution of 300 dots per inch (i.e., 1 inch of rotation moves the cursor 300 pixels). This resolution can be adjusted through software drivers to from 50 to 19,000 dpi. The mechanical part of the design is simply the rolling trackball. As it rolls, LEDs placed on either side of it provide the coordinate data for moving the cursor on the screen.

THE FACTS

TrackMan Stationary Mouse
Serial version, $139; bus version, $149.

Requirements:
IBM PC, XT, AT, PS/2, or compatible.

Logitech, Inc.
6505 Kaiser Dr.
Fremont, CA 94555
(415) 795-8500
Inquiry 984.

I tried the TrackMan using Logitech's Finesse desktop publishing software. I found the trackball to be easy to manipulate with my thumb. Indeed, the cursor followed my thumb movements precisely. When I wanted to click on a menu option, I simply pressed down my index finger. I was amazed how quickly TrackMan felt natural and intuitive to use—much faster, in fact, than my experience when first learning to use a mouse.

TrackMan may be the first mouse-like input device that is as easy to use as a conventional mouse. Because it does not require a surface on which to roll the trackball (it needs only enough room for the pad), it is ideal for use with laptops or desktop machines in confined areas (e.g., with a keyboard that's in a sliding drawer). An important feature of TrackMan is that you can use it on inclined or vertical surfaces, since the trackball can rotate only as a result of the motion of your thumb (it will not rotate due to external accelerations, as a mouse would).

The product includes Logitech's MouseWare utilities and drivers for adjusting the trackball's sensitivity and ballistic response (i.e., how much the cursor moves on the screen as you rotate the trackball). I think the Macintosh is an obvious target for TrackMan, but, unfortunately, TrackMan is not available for the Mac due to "contractual problems." (Logitech is an OEM supplier to Apple.)

TrackMan will probably not replace the mouse as the standard pointing device, but it may be the first attractive alternative to it. □

—Nick Baran

continued

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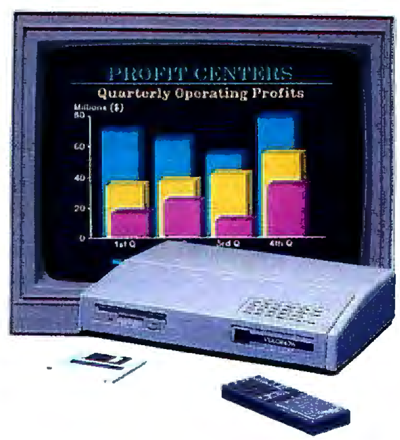

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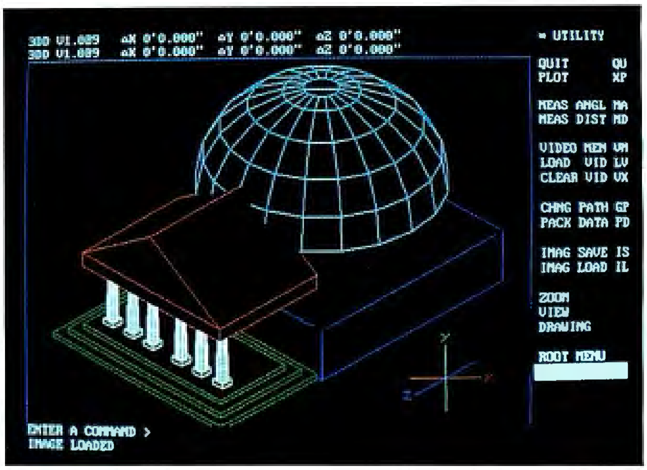


When BYTE's Product Focus looked at three-dimensional modelers in May ("The Third Dimension"), we omitted Generic Software's 3D Solids; it was simply Control Automation's ModelMate Plus under another name. Now there's a new three-dimensional modeler from Generic Software, **Generic 3D Drafting**, which builds on the strengths of the company's two-dimensional CADD products and solves the tricky problem of three-dimensional navigation in an elegant way.

Those using Generic CADD whose fingers automatically perform two-letter commands like ZB (zoom back) and DS (drawing save) will feel right at home in Generic 3D Drafting. If you're new to Generic CADD, that's OK, too. Menus provide a comfortable introduction; as you pick up speed, you'll find yourself bypassing them and reaching for the commands.

I skipped the tutorial and jumped right into a drawing of the BYTE pantheon. The whole process—from installation to the finished model—took about 5 hours.

Once I got my model off the ground, things went nicely. At first, I worked exclusively in the *x,y* and *x,z* planes, using a depth point to control the placement of objects.

Then I discovered tracking, and life got a whole lot easier. Just like VersaCAD Design and CADVance, Generic 3D Drafting works best in the isometric view (see the photo). Tracking works like this: To draw the slab that sits on top of the columns, I started with the BO (box) command and answered its query for a first point with TK (track). The tracking mechanism asks for an anchor; I snapped to the left front corner of the top step.

Then, using a three-dimensional cursor active in all three planes, I moved up 13 feet to the height of the top of the columns, set the slab's first point, moved right 34 feet to set its width, moved back 20 feet to mark its depth, and finally moved up 3 feet to mark its height. A running display of coordinates and a three-dimensional cursor trail make the tracking mechanism one of

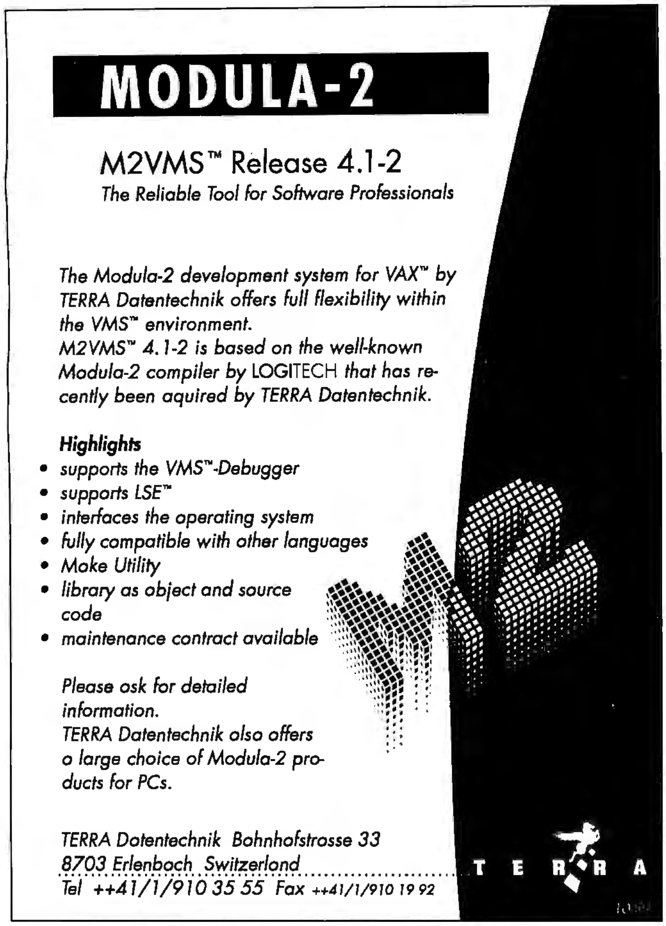
continued

THE FACTS

Generic 3D Drafting
$250

Requirements:
IBM PC AT or compatible with 640K bytes of RAM, EGA or VGA, and a mouse.

Generic Software, Inc.
11911 North Creek Pkwy. S
Bothell, WA 98011
(206) 487-2233
Inquiry 985.



the best three-dimensional navigational aids I've seen.

Generic 3D Drafting isn't perfect. It lacks conveniences like named views, named layers, multiple viewports, and a directory of drawings. It also lacks the horsepower of the best three-dimensional programs. Coons patches aren't supported, so I left the pendentives (arches) as an armature of arcs and Bézier curves. (You can, however, edit Bézier curves interactively.) Memory space is tight, so I had to reduce the number of facets in the model in order to get everything done. Also, hidden-line removal is slow—it took 90 minutes to render the pantheon on an ALR 386/33. Nevertheless, for $250 you get a substantial CAD program, which is a real deal. Generic 3D Drafting is off to a good start, and I expect that it will get even better. □

—Jon Udell

Large-Screen Eye Relief

Sampo hasn't cut any corners in quality with its 19-inch **KDS-1984 TriSync** color monitor. Instead of going the route of competitors whose multisynchronous monitors cover the gamut of handling everything from low-end monochrome TTL to high-end analog, the TriSync is an analog-only monitor that handles the three most-popular high-resolution standards: VGA, 8514/A, and Macintosh.

The TriSync is big, weighing 55 pounds. Since the unit I tested was a prerelease version, I got a bit frantic when I didn't find an instruction manual. (It hadn't been written yet.) But not to worry: If you can avoid a hernia while lifting it onto the desk, setting up the TriSync couldn't be simpler.

There are no DIP switches to set. I plugged the TriSync into my VGA card, turned it on, turned on my system, and voilà: an impressively large and perfect picture. The TriSync automatically sets itself.

It's not hard to get used to a large-screen monitor. I could easily lean back with my feet on the desk and the keyboard in my lap, while having no trouble at all seeing the characters on the screen.

The TriSync is particularly effective for GUIs (graphical user interfaces) like Microsoft Windows or OS/2 Presentation Manager. The windows and pull-down menus jump out at you. And with a maximum resolution of 1024 by 768 pixels (interlaced), the TriSync easily handles IBM's high-end 8514/A graphics card. Used in this configuration, it really shines for CAD applications.

Color quality is excellent. And with a 0.31-mm dot pitch, sharpness is excellent, even under close scrutiny. The TriSync does pull 85 watts of power and generates quite a bit of heat, but that's to be expected with a monitor of this size. The engineering problems involved with designing and manufacturing a large-screen high-resolution monitor aren't trivial, and Sampo has obviously put a great deal of work into making a top-quality product at a more-than-fair price. As far as I'm concerned, the eyes have it. ■

—Stan Miastkowski

THE FACTS

KDS-1984 TriSync
$1995

Requirements:
Analog graphics card for IBM PC (VGA or 8514/A) or Mac.

Sampo Corp. of America
5550 Peachtree Industrial Blvd.
Norcross, GA 30071
(404) 449-6220
Inquiry 986.

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Script Pica

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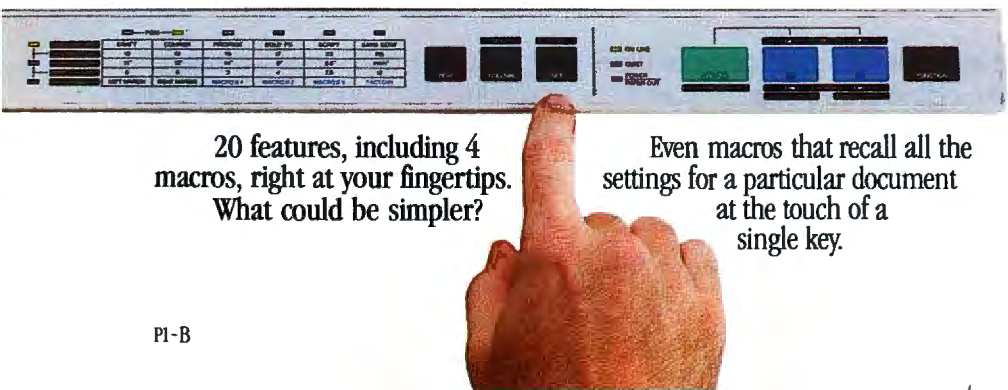

20 features, including 4 macros, right at your fingertips. What could be simpler?

Even macros that recall all the settings for a particular document at the touch of a single key.

True Notebook Computing Arrives

Frank Hayes

Slapped on everything from toner cartridges to shrink-wrap warranties, the word *revolutionary* is a commonplace label in the computer world. So maybe we need a new word to describe the GRiDPad. GRiD's new portable is the first "notebook computer" that you can really use like a notebook. It's small and light enough to cradle in one arm while you write with the other hand. And, as with a notebook, you can actually write on it—not just type. To make this possible, the GRiDPad is equipped with a touchscreen, a metal stylus, and optional software routines for recognizing handwritten letters and numerals and translating them into ASCII text.

In case you're not quite ready for a full-scale revolution, you can use this system as a fully functional MS-DOS-based laptop. The GRiDPad, with a list price of $2370, should be shipping by the time you read this.

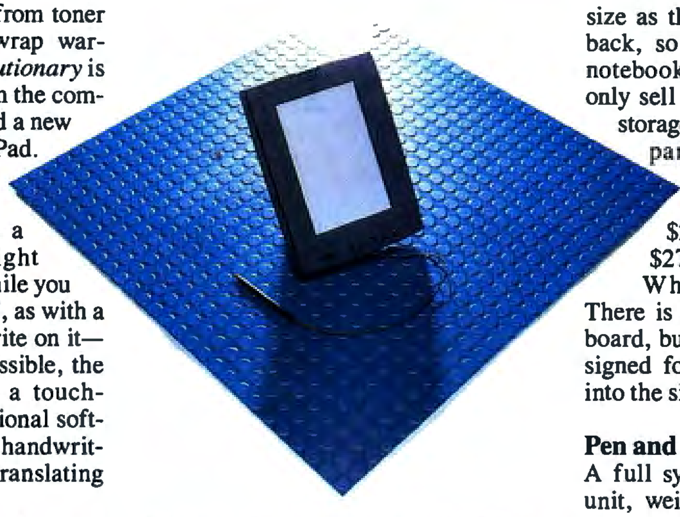

Photo 1: *The revolutionary GRiDPad.*

What It Is

Physically, the GRiDPad is a lightweight portable PC-compatible computer. It's slightly larger than the Tandy Model 100 (12½ by 9¼ by 1½ inches) and weighs 4½ pounds (see photo 1).

The GRiDPad's 8- by 5-inch non-backlit LCD screen takes up most of its top surface. The screen has a resolution of 640 by 400 pixels and normally works in double-scan CGA resolution. Five user-programmable buttons are on the GRiDPad's top surface. A 9-pin serial port is on one side of the pad, and GRiD's standard 2400-bps Hayes-compatible modem with MNP data compression ($695) mounts inside.

The GRiDPad's 10-MHz 80C86—a fully static CMOS version of the brains behind many laptops—operates at about twice the speed of a PC or XT. (Actual performance figures aren't yet available. We were unable to load the BYTE benchmarks because the prerelease unit that we saw did not have an external disk drive.) Standard RAM is 1 megabyte—640K bytes for DOS, plus 384K bytes of EMS memory. MS-DOS 3.3 is in ROM as drive C; drives A and B are RAM or ROM cards similar to those used with the NEC UltraLite. RAM cards are currently available in two sizes: 256K bytes ($335) and 512K bytes ($425).

Power comes from an external AC power supply or a removable battery pack. The battery pack is unusual because it can take either a bank of nickel-cadmium batteries, which automatically recharge when plugged into the power supply, or 10 AA cells. GRiD doesn't recommend trying to run the GRiDPad regularly on AA cells (that could get expensive very quickly), but it's a nice feature to have in case of an emergency.

An internal bridge battery keeps the computer alive for about 5 minutes while you change the batteries. GRiD says the nickel-cadmium batteries will last 8 hours or more between charges, depending on how they're used.

Like most of the recent clutch of portables, the GRiDPad achieves long battery life through a sophisticated power management system. A switch on the front of the machine sends the GRiDPad into "sleep" mode, which stops the CPU and cuts the power to most subsystems except memory. You can also set the GRiDPad to go into sleep mode automatically after a certain period of idleness.

An optional expansion unit ($1000) adds 3 pounds to the GRiDPad's weight; it includes a 20-megabyte, 29-millisecond hard disk drive, a parallel printer port, its own removable battery, and a port for an external 3½- or 5¼-inch floppy disk drive or tape backup drive. The expansion unit, which is the same size as the main system, clips onto the back, so the combined unit retains its notebook-size dimensions. GRiD will only sell the GRiDPad with at least one storage device: a RAM card or the expansion unit with its hard disk drive. As a result, although the GRiDPad's list price is $2370, it will cost you at least $2705 to own one.

What's missing? A keyboard. There is a port for a conventional keyboard, but the GRiDPad is primarily designed for use with a stylus that plugs into the side of the machine via a tether.

Pen and Display

A full system, including the expansion unit, weighs in at a little more than 7 pounds. Add a keyboard (say, 4 pounds more), and it's a respectable conventional laptop computer, although it would be tough to balance on your lap. The display can be configured as a double-scan CGA screen, and it's sharp and easily readable. GRiD even offers a "standle"—a combination stand/handle for setting the screen upright on a desk.

But the "Pad" in GRiDPad stands for "pen and display," and that's how it's really designed to be used: as a lightweight electronic pad. For example, you can boot the GRiDPad with no keyboard attached and a split-screen display: The top half is a flattened 640- by 200-pixel CGA screen, while the bottom half is a diagram of a keyboard. Touch an on-screen key with the stylus, and the character appears on the command line as if you'd typed it. It's no replacement for touch-typing, but it's perfectly adequate for simple commands.

However, the GRiDPad goes this virtual keyboard one better: Programs written specifically for the GRiDPad can also do limited handwriting recognition. With the right software, you don't have to type at all—just print in block letters, and the system converts what you've written into ASCII text.

It's important not to overestimate the GRiDPad's abilities in this area. GRiD warns that it generally takes a user about 15 minutes to learn to print so that the GRiDPad can understand it. But the day that GRiD representatives showed the computer to us at BYTE, I printed words and numbers immediately with no diffi-

New laptops from Compaq, GRiD, Toshiba, and Zenith point to the future of small computing

Laptops Forever

EISA, GUIs, the 80486, and the 68040 are interesting because they are the future. But laptops are the most exciting advancements in microcomputer technology that you can buy today. A look at systems that BYTE has already covered this year—the NEC UltraLite, Zenith MinisPort, Agilis System, Poqet PC, Atari Portfolio, and Macintosh Portable—proves the point.

Laptops are getting smaller, running longer on batteries, challenging the performance of desktop units, and just plain getting better in terms of functionality. Some are going where no computer has gone before—hostile factory and remote locations, on the road with truck drivers, and in numerous other work environments where, until now, a personal computer has been too unwieldy.

This month, we take an early look at five more small personal computers: GRiD's fascinating GRiDPad, Compaq's notebook-size LTE/286, Toshiba's T1000SE (a refined T1000), and two powerful 80386SX systems from Zenith and Toshiba.

culty. In a few cases, I had to print a word or number several times before the computer translated it properly. But that was not much of a problem; when the GRiDPad got it wrong, I just drew a line through it; the software cleared the word or number, and I tried again.

It's eerie to watch block printing turn into typed text one word at a time. And it's amazing to realize that anyone who can fill out a form can use the GRiDPad—all you have to do is print clearly. It's also a little disconcerting to write on the textured glass surface of the GRiDPad's screen, which uses a capacitance-based system to get a resolution of 1024 by 1024 pixels. GRiD says the surface can't be scratched by the stylus, although the screen itself can break.

Along with the optional handwriting-recognition routines in ROM ($70 per machine for a run-time license, plus $125 per machine for a user interface run-time license), there's a complete set of other routines plus an application programmer interface that allows programmers to write software to take advantage of other GRiDPad features. For example, this computer has no "right-side up"; a programmer can design a GRiDPad program to rotate itself from landscape to portrait orientation, or flip itself around so the stylus is more convenient for left-handed users. The stylus can be made to imitate most mouse actions (you can "click" by tapping on the screen with the stylus, or "drag" by drawing on the screen), but there's no need for a mouse pointer on the screen—the stylus is its own pointer. The GRiDPad API also has extensive telecommunication capabilities built in, along with features to simplify designing on-screen forms. (GRiD is offering a developer's kit for programming with the API in Microsoft C and Borland's Turbo C.)

Better Ideas = Better Computers

The GRiDPad demonstrates something that we thought computer makers had forgotten: More powerful computers don't necessarily come from faster CPUs or more memory, but from better ideas. We've seen a whole string of self-styled portable computers over the last few months, ranging from Atari's inexpensive Portfolio to Apple's hefty, bulky Macintosh Portable.

The GRiDPad isn't the fastest or most memory-laden machine in this wave. And with a base price of $2375, it is certainly not the least expensive. But it may be the first truly portable computer we've seen, and it's certainly the easiest to use. It has Macintosh-style friendliness both on the screen and in its physical design.

In the future, GRiD might offer utilities that would allow off-the-shelf software to take advantage of the GRiDPad's special features. For example, special drivers could let you input handwritten text into Lotus 1-2-3 or use the stylus in place of a mouse. But for now, those special features are limited to use with software that's specially designed for the GRiDPad.

With this custom software, the GRiDPad is a unique computer. Because it's so lightweight, it's easy—even natural—to use while you're standing or walking around; you just cradle the computer in one arm and write with the other hand. And the stylus and handwriting-recognition software do away with the need for a keyboard, which poses the biggest barrier to most users. It's worth repeating: Anyone who can print clearly enough to fill out a form can use this computer.

And that's precisely the initial market that GRiD is counting on for the GRiDPad—the largely unautomated world of forms. The GRiDPad can easily mimic anything that a real paper form can do (since the stylus acts and feels like a real pen) while adding the power of a computer. On a sales form, for example, it could let you choose products from a menu while verifying prices, double-checking arithmetic, comparing quantities to previous orders, ensuring that all necessary parts are included in your order, and letting you sign the order form, all about as easily as you'd do it using an ordinary clipboard. That's a good way to use the GRiDPad, but it's far from the only way: Using it just for forms makes about as much sense as using the Macintosh only to run MacPaint.

In a year of innovative portable computers, the GRiDPad is easily the most innovative of the group. It's perhaps the most revolutionary computer of any kind since the Macintosh. And just as the Mac required a whole generation of programmers to consider how a mouse changes the way that software works, the GRiDPad is going to spur some even more fundamental rethinking.

For nearly 20 years, computer designers have tried to match the dream of Alan Kay's "Dynabook"—a portable, powerful, user-friendly computer. Although the GRiDPad isn't it, it brings the millenium a lot closer. □

Frank Hayes is BYTE's West Coast news editor. He can be reached on BIX as "frankhayes."

continued

Compaq and Toshiba Take the Low Road

Michael E. Nadeau

The "Holy Grail" being sought by laptop vendors and users alike is a system that's as small and light as possible, yet sacrifices nothing in terms of performance, functionality, or compatibility. So far, this search has yielded products that compromise on one or more of these attributes.

Compaq and Toshiba have new laptops that represent milestones in this quest, although in different senses. Compaq has squeezed all the power of a 12-MHz 80286 desktop system into a notebook-size box, complete with hard and floppy disk drives. And Toshiba's T1000SE is an improved version of its classic T1000, which is itself a milestone product.

Both computers are aimed at professionals who need to compute on the go: salespeople, executives, field personnel, and journalists, for example. What separate the two are price and power.

Photo 2: *The Compaq LTE/286 (left) and the Toshiba T1000SE.*

Design Philosophies

I can't decide whether Compaq has taken a radical or a conservative approach in designing its small laptop computer, the LTE. Rather than use the new RAM card technology that's currently in vogue for mass storage on laptops, the company maximized the conventional method by minimizing the physical size of the floppy and hard disk drives. Compaq then shrank the circuit boards, making the most of surface mount technology (SMT). The end result is a 6.7-pound (including hard disk drive) AT-class PC that measures 8 by 11 by just under 2 inches (see photo 2).

RAM cards, though expensive and not standardized, have been touted as a breakthrough for small computers, allowing engineers to shrink the laptop ever further. Yet Compaq bucked the trend, and the result is one of the smallest and arguably most powerful mini laptops available (see the benchmark results in table 1). Best of all, the LTE doesn't *seem* small. Compaq hasn't sacrificed functionality for size.

The Toshiba T1000SE appears to be more conventional than the LTE. Its dimensions, 12⅖ by 10⅕ by 1⅘ inches, come closer to a "standard" laptop size. It's lighter than the LTE: 5$\frac{9}{10}$ pounds versus 6 pounds (sans hard disk drive). But Toshiba achieved the light weight by making a compromise that Compaq didn't. The T1000SE won't accept a hard disk drive; instead (and this is where Toshiba broke with conventional laptop design), it is limited to the now-ubiquitous battery-backed RAM card for optional storage capacity. Maximum storage on the RAM card is 2 megabytes—far from the 40 megabytes available on the LTE.

Compaq also provides more power for those who need it. The 80C286-based LTE/286 with an optional math coprocessor runs rings around the T1000SE (see table 1), but Compaq compromised, too. The T1000SE's CGA resolution is 640 by 400 pixels; the LTE's is 640 by 200 pixels. The Compaq's keyboard is a bit more compact with less key travel, too. These are concessions to achieving the smaller form factor.

The LTE is a new addition to Compaq's computer line, filling a hole in the low end of its laptop offerings. Toshiba has positioned the T1000SE between the T1000, long a best-seller among low-end laptop computers, and the hard disk drive version of the T1200.

Compaq will ship the LTE by the time you read this; Toshiba says the T1000SE will be available in January.

The Compaq Twins

The LTE actually comes in two versions: a 9.54-MHz 80C86-based LTE and the LTE/286, which I used for a couple of weeks. They are identical except for the CPU. Prices range from $2399 for the LTE Model 1 (which has 640K bytes of RAM, a 1.44-megabyte 3½-inch floppy disk drive, and no hard disk drive) to $2999 for the Model 20, which has a 20-megabyte hard disk drive. The LTE/286 comes in three basic configurations: the Model 1, with 640K bytes of RAM and a 1.44-megabyte 3½-inch floppy disk drive ($3899); the Model 20, with a 20-megabyte hard disk drive ($4499); and the Model 40, with a 40-megabyte hard disk drive ($4999). Only the LTE/286 accepts a math coprocessor.

Each version has two small proprietary expansion slots on the right side—one for either a 2400-bps modem ($449) or an asynchronous communications card ($149), the other for memory. The tiny modem card measures only 3¼ by 2¼ inches. It has nearly the same design as the modem for Compaq's SLT/286, and it, too, benefits from Compaq's SMT engineering know-how. Maximum total memory for the LTE is 1 megabyte; for the LTE/286, 2.6 megabytes. Other options include a numeric keypad ($119) and a fast charger for the battery ($199).

The screen is a CGA-compatible backlit electroluminescent supertwist LCD with 640- by 200-pixel resolution. Its two distinguishing features are its thickness (a quarter of an inch) and the ability to switch from reverse to normal video. You adjust contrast and brightness via slide controls, and you can adjust its position a full 180 degrees. Screen quality is good, and the ability to switch video modes is a nice feature.

A standby button lets you shut down the LTE while maintaining the memory contents in RAM. The LTE comes standard with one serial and one parallel port, a video port, and an external floppy disk drive connector.

The 80-key keyboard is only a half-inch thick, yet it provides good tactile response with a clearly audible click. The keys are not full-travel. All the function keys and most of the non-alphanumeric

continued

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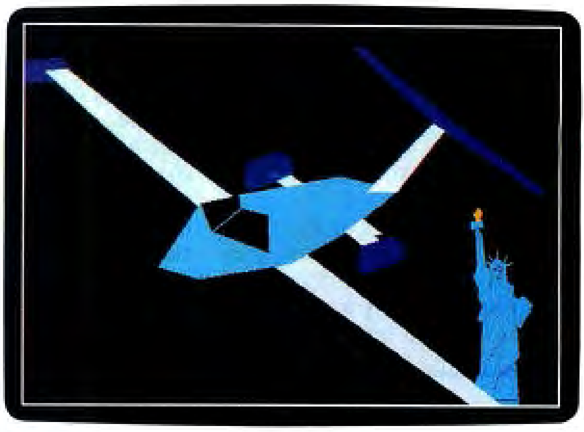

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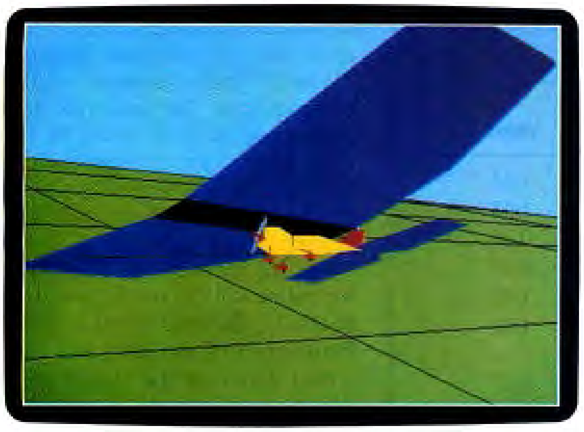

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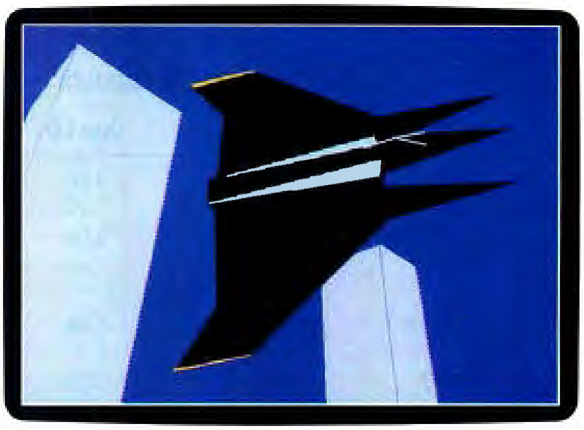

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keys are about half of normal size—another trade-off (see photo 3). The key placement took some getting used to, but I found the keyboard to be acceptable.

In the "nice touch" category, Compaq put some thought into designing the LTE's case. It looks rugged; the cover latches hold firm, and tabs on the cover fit into grooves on both the battery and expansion slot doors, preventing them from opening unexpectedly when you jar or move the LTE. The machine has no handle, but its slipcover does.

Battery life is rated at 3½ hours, but I got nearly 4 hours on a battery that Compaq had been using for an unknown length of time for demonstrations. Recharge time is 8 to 10 hours (1½ hours with the fast charger). An optional automobile adapter ($129) powers the system from a car cigarette lighter and can also recharge the battery pack. The LTE comes with an AC adapter.

A power management include utility, Powercon, lets you set the amount of idle time before the system blanks the screen, puts itself to "sleep," or turns off the hard disk drive. The LTE's other standard utilities include the Compaq Extended Memory Manager, an Adapt display utility, and a disk-caching utility. MS-DOS 3.31 costs $120; version 4.01 is $150.

Table 1: *These BYTE benchmark indexes are preliminary, since we ran them on preproduction units, but the results are interesting. The Compaq is not only the smallest 12-MHz laptop we've tested, but it appears to be one of the fastest as well. Both the Toshiba T3100SX and the Zenith SupersPort SX are among the fastest 80386SX systems, including desktops, that we've tested. Other systems' ratings are shown for comparison. None of the units were equipped with math coprocessors.*

BYTE BENCHMARK RESULTS

	CPU	Disk I/O	Video
Compaq LTE/286	1.59	1.26	1.43
Compaq SLT/286	1.59	1.77	1.43
Toshiba T1000SE	0.57	3.09	0.79
NEC UltraLite	0.93	1.42	0.80
Toshiba T3100SX	2.12	*	1.79
Zenith SupersPort SX	2.07	1.98	1.82
NEC PowerMate Portable (80386SX)	1.96	1.23	1.27

For all indexes, an 8-MHz IBM PC AT=1. For a full description of all the benchmarks, see "Introducing the New BYTE Benchmarks," June 1988 BYTE.

* Benchmarks were run under MS-DOS 4.01, which skewed the results of the DOS Seek portions of the Disk I/O tests on the T3100SX.

Photo 3: *At only three-quarters of an inch high, the Compaq LTE/286's hard and floppy disk drives are the smallest ever. Note the two sizes of keys on the keyboard.*

Getting Small

Compaq concentrated on reducing the physical size of the system's motherboard and floppy and hard disk drives. According to David Black, Compaq's director of product development, the company made use of SMT engineering know-how that it gained from designing the Compaq SLT/286. SMT allows system designers to put a greater density of application-specific ICs in a given board area. The motherboard measures only 7½ by 2½ inches, minus a small notch to accommodate the hard disk drive, and makes use of both sides. It holds the CPU, math coprocessor socket, and supporting chips. A second board on top of the motherboard holds I/O and other miscellaneous circuitry.

But the real stars of Compaq's miniaturization efforts are the disk drives (see photo 3). Compaq worked with Conner Peripherals on the hard disk drive, and with Citizen on the floppy disk drive, which uses standard 1.44-megabyte floppy disks. Both measure only three-quarters of an inch high, one quarter of an inch shorter than conventional drives. The hard disk drive consumes roughly a half watt less power than the one used in Compaq's SLT/286.

The Conner hard disk drive is particularly interesting in that most of its ability to withstand shock is internal; the LTE is too small to have much shock absorbency built into the case or drive mounts. According to Compaq, this drive will withstand a shock force of 400 g's—enough for peace of mind on the road.

Improving an Old Favorite

I've had a love/hate relationship with BYTE's old Toshiba T1000. It's relatively easy to lug around on trips, but I was going blind trying to read its screen, and growing old waiting for it to load XyWrite from its floppy disk drive. The T1000SE addresses those problems and appears to be a solid upgrade. Compared to what Compaq has done with the LTE, the T1000SE comes up short in the performance-per-pound department. However, it will appeal to users who don't need the horsepower or a hard disk drive.

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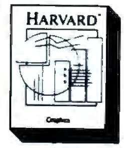

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COMPANY INFORMATION

Compaq Computer Corp.
(LTE/286)
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Inquiry 1170.

GRiD Systems Corp.
(GRiDPad)
47211 Lakeview Blvd.
Fremont, CA 94538
(415) 656-4700
Inquiry 1171.

Toshiba America Information Systems, Inc.
(T1000SE, T3100SX)
Computer Systems Division
9740 Irvine Blvd.
Irvine, CA 92718
(714) 583-3000
Inquiry 1172.

Zenith Data Systems
(SupersPort SX)
1000 Milwaukee Ave.
Glenview, IL 60025
(800) 553-0331
Inquiry 1173.

A 9.54-MHz 80C86 CPU powers the T1000SE (see photo 2). For its base $1699 price, you get a 1.44-megabyte 3½-inch floppy disk drive, 1 megabyte of RAM, PC-Kwik Power Pak performance utilities, and on-line documentation. MS-DOS 3.3 comes standard in ROM as drive C. In addition to the single RAM card slot, the Toshiba has a slot for a 2400-bps modem. RAM cards come in 1-megabyte and 2-megabyte capacities. (Toshiba had not released prices for these and other options at press time.) Also standard are serial and parallel ports, as well as an external floppy disk drive port. SMT is used extensively throughout the T1000SE as well.

Toshiba intends the RAM cards to be used as a battery-backed RAM disk. To the user it appears and behaves as a hard disk partition D. You can place your most-used applications on it for quick access. A separate battery in the T1000SE maintains the RAM card's contents when the power is shut off; removing the card erases its memory. If your applications won't fit into 2 megabytes of RAM, you should consider either running some of them from floppy disks or getting a laptop with a hard disk drive.

The screen's greater resolution provides more-readable text and better graphics than the LTE's. Brightness and contrast controls are on the side. The flip-up screen tilts 120 degrees.

For a computer of its size and price, the T1000SE has a surprisingly nice keyboard. Its 82 keys have the feel of those of a full-size keyboard, and my adjustment to the keyboard was minimal.

The case on the preproduction unit I saw didn't seem as rugged as the Compaq's. The doors for the external connectors were hard to open and close, and the battery door was difficult to remove. The single front latch for the screen looked easy to jar loose. The final production case might be better, but for rough duty, the optional carrying case is a must.

The rated battery life is a meager 2½ hours, which means you better have a spare battery pack for long airplane flights. Recharge time is a reasonable 4 hours. An AC adapter comes standard with the T1000SE, and Toshiba offers an automobile adapter as an option. A power management utility lets you specify how long the system can remain inactive before shutting down the screen and modem. It has an "auto-resume" feature; once it's enabled, you can shut off the computer, and it will pick up where you left off when you turn it back on.

The Outlook

Building smaller laptops is the science of compromise. As a buyer, you look for the system that compromises the least on features that are important to you. Their design goals differ, but Compaq and Toshiba seem to have built two nice laptops.

For me, the choice is easy. There's just no substitute for a hard disk drive—at least not yet. It's cheaper, it holds more data, and there's no worry about future compatibility problems. I'll take the Compaq LTE/286; its size is just right, and it appears built to take a lot of abuse. Other laptops have better screens and keyboards, and some are lighter, but these are picky points compared to the LTE/286's overall functionality.

But many users take a computer on the road to do one or two simple tasks, such as word processing. A T1000SE with 1 megabyte in a RAM disk is more than up to the task. Its large screen and excellent keyboard are good selling points, too, especially to T1000 users looking to upgrade. Prospective buyers must factor in the cost of the RAM cards, carrying case, and spare battery pack, though. □

Michael E. Nadeau is BYTE's associate managing editor for reviews. He can be reached on BIX as "miken."

continued

Lug 'Em or Leave 'Em

Stan Miastkowski

The past few months have seen a veritable flood of both desktop and laptop computers based on the Intel 80386SX processor. Compared to a full-fledged 80386 chip, the 80386SX is a logical choice for a portable computer. It costs less, requires fewer support chips, and consequently uses considerably less power, allowing systems to be battery-powered. And while its 16-bit data path won't set any performance records, the 80386SX's 16-MHz clock speed is faster than that of most AT clones (see table 1), while at the same time providing some of the advantages of the 80386, such as the ability to run 80386-specific applications.

Zenith and Toshiba have just released two of the very first battery-powered 80386SX-based portable computers. We recently had a chance to look at prerelease versions of both.

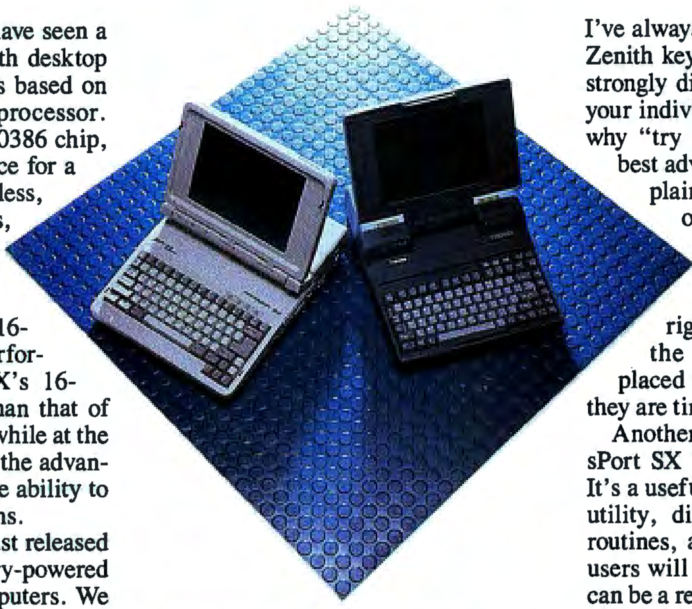

Photo 4: *The Zenith SupersPort SX (left) and the Toshiba T3100SX.*

Commonalities

As you might expect from two of the industry's leading laptop makers, both the Zenith SupersPort SX and the Toshiba T3100SX are impressive and well-built machines that tilt toward the high end of the performance and price scales. They are slower than 80386-based laptops, faster than the top-of-the-line 80286-based laptops, and, at about $6000 each, not exactly the type of systems you'll find in the hands of every traveler or casual portable computer user.

Both have processors running at 16 MHz (switchable to 8 MHz). Both also come standard with a 40-megabyte 25-ms hard disk drive and a 1.44-megabyte floppy disk drive. Other common standard features include a megabyte of RAM, VGA-compatible displays, and the usual contingent of serial, parallel, keypad, and external disk drive ports.

It still takes a lot of power to run systems like these. The battery packs are substantial in size and weight. If you can't live without battery power, both systems use fast rechargers to bring dead systems back to full power in about 3 hours. Both companies claim their systems will run for a minimum of 3 hours on batteries, and both machines use a variety of sophisticated power-saving features (e.g., turning off the hard disk drive) to keep the power flowing.

When it comes to future expansion, both systems also offer similar paths. Among these are memory cards, internal modems, and extra batteries.

Zeroing in on Zenith

The Zenith SupersPort SX is a sleekly designed cousin of the SupersPort 286 (see photo 4). Its distinctive ivory case sets it apart from the competition, which seems to often opt for the more-trendy dark gray or black.

Zenith's computers have always been full of thoughtful touches, and the SX is no exception. As with the 286, the SX's battery pack detaches from the rear of the computer. You often don't need the battery, and you save nearly 5 pounds without it. Sans battery, the SX weighs in at a more reasonable (though still far from light) 12 pounds.

The Zenith's screen is an absolute pleasure for the eyes, with the company's well-known "page-white" LCD screen now made even better with VGA compatibility. The 10-inch screen uses 16 shades of gray for color emulation, has incredibly bright fluorescent backlighting, and tilts through a full 180 degrees.

Keyboards are probably one of the most subjective areas in laptop design. I've always liked the slightly soft feel of Zenith keyboards, while a fellow editor strongly dislikes it. It really depends on your individual style of typing, which is why "try before you buy" remains the best advice. But I do have a few complaints about the SX's 79-key layout, which remains staunchly quirky. For example, the backslash and single quote keys are located at the far right beyond the Shift key. And the cursor keys *seem* logically placed in the lower right corner, but they are tiny and cramped.

Another singular feature of the SupersPort SX is the built-in monitor ROM. It's a useful feature that includes a setup utility, diagnostics, directable boot-up routines, and a debugging utility. Most users will never need this feature, but it can be a real lifesaver when you do.

Toshiba's Not-So-Trendy Portable

At first glance, the Toshiba T3100SX bears a striking resemblance to the rest of Toshiba's well-known line of laptops (see photo 4). The resemblance remains at second (and third) glance, too. The company's boxy, dark-gray cases have been around for quite a few years now. And while they might not look as sleek as the competitors', they're built like tanks.

The Toshiba's battery pack isn't detachable; you're stuck with the extra weight whether you need it or not. The T3100SX weighs in at just a hair under 16 pounds—not the most ideal weight for hefting through multiple airplane connections.

Like Zenith, Toshiba has added VGA compatibility to the T3100SX, although the company still uses its venerable "low-power gas-plasma display technology" that gives you a black-on-amber display. I've always found gas-plasma screens to be an acquired taste. Although I prefer the Zenith's paper-white screen, the Toshiba's is admittedly easy on the eyes, even after hours of nonstop use.

Toshiba's AutoResume feature is one that every laptop should have. When you turn off the system, the state of the machine is saved in the CMOS memory. Turn it back on later, and you'll be exactly where you left off. This also saves battery power.

The T3100SX has an 86-key keyboard

with a stiffer feel than the Zenith's. Again, although keyboard feel is a subjective call, the layout of the keys on the T3100SX seems cleaner and more logical than the SupersPort SX's. I found that I didn't have to search endlessly for common keys.

Toshiba has also packed in more standard software than Zenith (the SX comes loaded with DOS 3.3 only). Besides DOS 4.01 (which gives you an optional graphical user interface), the T3100SX comes with Quarterdeck's QEMM-386. Although it's not particularly useful if you only have a megabyte of RAM, this software opens up new horizons when you equip your system with more memory.

Trend of the Future

Both the Zenith SupersPort SX and the Toshiba T3100SX are powerful computers. While their performance doesn't meet the full-fledged power of a true 80386 system, that extra edge of the 80386SX can come in handy for users who need a bit more processor muscle for serious spreadsheet or database work in the field.

While the power of the 80386SX isn't exactly overwhelming, these are fleet systems, especially if you're used to an 80286-based system. And while they're useful now, their real power lies in the near future, when applications specifically tuned to the 80386 start to arrive in quantity.

But what's disturbing about both of these systems is that 80386SX-based portables are bringing more weight to the laptop market at a time when users are becoming enamored of lightweight (albeit expensive) small portables. The Zenith's removable battery pack is a feature much in its favor.

Finally, there's cost. Laptops are stubbornly refusing to come down in price. As you'd expect, the 80386SX systems cost more than 80286-based portables, and less than 80386-based laptops. But $6000 is a significant amount of money in any situation, and when the 80386SX chip was first introduced, the point of it was ostensibly to create powerful and low-cost systems. That hasn't happened yet. Thus, unfortunately, these 80386SX systems seem destined to remain with executives or with other power users. ■

Stan Miastkowski is a BYTE consulting editor, managing editor of K+S Concepts (a documentation and consulting firm), and editor of the OS Report *newsletter. He can be reached on BIX as "stanm."*

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InfoWorld 1986 87 88 PRODUCT OF THE YEAR

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NEW!

The Pascal library provides interfaces for the entire set of API functions. It supports Turbo Pascal V4.0 and V5.0 compilers. Included are the API Reference Manual, source code for the library, and example programs.

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API Panel Designer

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More Tools are Coming

Quarterdeck is committed to adding tools as needed by our users. To that end we have been working with Ashton Tate and Buzzwords International on dBASE III and dBASEIV translators. And in the works, we have BASIC and DOS Extender libraries.

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A Look Backward and Forward

Jerry reminisces about the beginnings of microcomputers and looks at new products of today

This issue not only marks the end of the 1980s, it's also part of the celebration of BYTE's fifteenth year of publication. When my crack technical editor Stan Wszola reminded me of that, he also reminded me that except for my ace copy editor Warren Williamson, I have the longest service of anyone in BYTE's editorial department. I didn't quite start at the beginning. I did *read* the first issue of BYTE, but it wasn't until 1976 that I let my mad friend Dan MacLean persuade me that I needed a personal computer and borrowed the money to let Tony Pietsch build it.

I'd always secretly been in love with computers, but the incentive for buying one wasn't to own a computer per se: it was an application called Electric Pencil. The first time I saw Electric Pencil demonstrated, I realized that if I had that, I would never again retype a page of text as long as I lived; and I fell instantly, irretrievably, and irrevocably in love.

It wasn't until after I got Ezekial, my friend who happened to be a Z80 computer, that I realized that computers don't just let you write quicker—they also make your work better. Before small computers, if you made serious changes in a page of text, you ended up retyping not only the changes but the entire page.

That's hard work. The result was the "clean draft" syndrome: you have a nice clean draft of your novel—and you find paragraphs that ought to be rewritten. Sentences that should be recast. Words to be eliminated. You know the work would be improved—but there it is, a clean draft. If you tear things up, it will have to be retyped, either by you or by a typist who won't at all appreciate having to do that job over yet again. Isn't it good enough the way it is?

But once I had Zeke, this was no problem. I wrote a draft and then printed it out and edited with pen and ink as I always had; but when I had it all marked up, it was no great trick to enter my changes and then tell Zeke to make a new copy. He didn't mind at all.

About that time two things happened: the BYTE editorial staff came to the West Coast for a computer show, and I got to worrying about my taxes. My friend Zeke had cost me $12,000 (about half that was for the Diablo letter-quality printer). It wasn't at all clear that the Internal Revenue Service would consider a computer a legitimate deduction for a writer; this was, after all, long before "word processors" became common—indeed, before the phrase was invented. I might be able to convince their auditors that I needed the computer—and I might not. But if I could make the machine earn some revenue....

At the computer show my son Alex, still in high school but very much fascinated with computers, came over to me and asked: "Do you want to meet the famous Carl Helmers?" Shortly after that I was talking with Helmers, BYTE's editorial director, and Chris Morgan, the editor in chief; and before the day was out, they had commissioned an article about writing with computers (see "Writing with a Microcomputer," *onComputing*, Summer 1979). I was then the science columnist for *Galaxy Science Fiction*, so the column format suggested itself; the article became a column; and Warren Williamson has been struggling with my semicolons ever since.

The Computer Revolution

In those days, we thought there might be a million small computers by 1987. A few of us predicted there would be even more, but we were considered mildly insane. After all, these were *computers*. You couldn't just go into a store and buy one. Instead, you had to think about what kind of computer you wanted: one of the all-in-one systems like the Commodore PET or Exidy Sorcerer; a dedicated word processor that might or might not turn into a computer later on, like the Wang; or a general-purpose system with a card cage, bus, and cards, preferably an S-100 bus. Suppose you chose the S-100. Fine. What kind? Imsai, with flashing lights and big front-panel switches? A Cromemco "black brick," with no front panel at all, and thus no flashing lights?

What did you use to communicate with the computer? Larry Niven's wife went out and bought an Altair and a teletype machine, complete with paper-tape reader; but that was for games, not writing. Should writers go with memory-mapped video or a terminal of some kind? And what keyboard would we use?

Even more important, what kind of disk system? Just about every brand of disk drive had a proprietary format—and its own operating system! When I first got Zeke, he came with an incredibly clumsy system known as FDOS.

Then came CP/M, and the world changed.

The Great Power Spike Continued

We were able to fix everything after the 16-kilovolt power spike (see "The Great Power Spike," August). I still don't have a new power supply for the Priam 330-megabyte MacDisk, so that drive continues to sit in a case belonging to a discarded WORM (write once, read many times) drive; but other than that, there are few signs of the devastation—except that every bit of electronic gear is now plugged into surge protectors.

On that score, I find that while most of the protectors we use bear Priority One's brand name Compuguard, they are all made by an outfit named Data Shield

continued

Solid-State Controls, which also makes protection equipment that is sold under BusinessLand's Compu-Guard label. They say they guarantee their work and will send me replacements for any of their units that died while saving my equipment. Let me again emphasize that no equipment that was protected by Data Shield/Compuguard surge protectors was harmed in any way, and that the need for surge protection is no myth.

Second, the Clary people examined my uninterruptible power supply (UPS) that had survived the spike (the Northgate 386 plugged into it continued running as if nothing had happened) and found it unharmed; it would have been able to protect my equipment even if the unlikely power spike happened again. They sent me pictures of the machine's innards.

Third, three weeks later I did have a minor incident with the TSi UPS 3150: we had a mini power failure, one that just barely blinked the lights; and while it did no harm at all, the computer that was plugged into the TSi UPS reset itself. The one plugged into the Clary UPS didn't notice that we'd had a problem. Since I've tested the TSi several times by yanking its power cord, I can only conclude that the on/off was just rapid enough to trigger a reset without triggering the TSi's backup power. I like the TSi unit: it's small and compact, and I haven't been able to zap the power on and off fast enough to duplicate the event, so I've left it on-line.

Flash: it's raining, and we have had a dozen microcomputer power failures since I began writing this. Each time the TSi made a slight buzzing noise, but my work was undisturbed. Wonderful.

I've said this before, but it bears repeating: if you do serious work on computers, whether program development or CAD or word processing, and you don't have a UPS, you ought to rethink your situation. If you run Unix and you don't have a UPS, you should see a psychiatrist.

Remote Keyboards

For me it started with a gizmo named Remote Keyboard, a hand-held device that would let you wander about a lecture hall giving a speech and still be able to control presentations on a PCompatible. I used it for a pitch in conjunction with Traveling Software's gadget that projects your PC output through an overhead projector (also a portable I got from Traveling Software's catalog). Then Alex used it in one of his presentations to a client. Worked fine.

Then came a flood of them. There must be a dozen different brands of remote keyboard controllers.

One stands out from the others. It's called SilentPartner (trust me: the unit works better than the name implies), and unlike Remote Keyboard, which plugs into the serial port, this works with the serial port as well as the keyboard port. It can also be used with portables that don't have a keyboard port. I'm particularly impressed by the software that comes with it. It supports macros, and when it's working through the keyboard port, these are keyboard macros: they get their intercept before the computer ever sees the characters. This makes it pretty well guaranteed that they won't interfere with applications software, including Windows and SideKick and various other hot-key stuff. I even had SilentPartner working with DESQview.

The unit has legends that glow in the

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dark, although they don't glow brightly enough to make much difference, or didn't at the light levels I'd use for a PC presentation. Oh, well. You can't have everything.

If you're into remote hand-held controllers for your PC, look at Silent-Partner. Recommended.

IPSS

Every now and again I get a program like Interactive Population Statistical System that makes me want to drop everything and spend a couple of weeks playing with my computer. If this column weren't due this weekend and *Wrath of God* overdue already, I'd probably be fooling around with IPSS yet.

Of course, I've been interested in population projections since the Boeing Co. had me take a seminar with Herman Kahn in 1959. One of the things Herman taught was just how much of the future is not only predictable, but obvious. Population projections, for instance: given the age pyramid, certain conclusions follow inevitably.

For example, the U.S. *must* increase productivity: we have a declining work force and increasing numbers of elderly people. The Social Security program of the U.S. is a gigantic Ponzi scheme: the next generation of workers supports the previous one. This isn't necessarily bad—so far no one has gone broke betting on the future of the U.S.—but it does mean that each generation must produce enough to take care of itself and have enough left over to take care of the retired.

The problem is that each generation naturally expects more than the last, meaning that each must produce more. If there are also more workers, productivity per worker needn't rise much; but if there are fewer workers, productivity must rise, or there is no way to pay the current work force and also fund the Social Security obligations to the previous generation (whose Social Security taxes were long ago spent to pay for the generation previous to *that* one). As I said, a Ponzi scheme; and where it runs into trouble is when it's clear there will be *fewer*, not more, workers.

The U.S. has a declining work force, and if it were not for immigration, we would soon have a declining population. Note that even if next year starts a new baby boom, it will be 18 years before that has any effect on the number of productive workers.

When I first got Zeke, I wrote a number of population-study programs in BASIC. They were crude little models, but they were better than anything I'd ever seen, including those used by the Bureau of the Census and the Department of Labor Statistics. I used them to make a number of projections, most of which inevitably "came true," so that in some circles I got the reputation of being a prophet, when all I did was let the computer show me the obvious.

Now there's IPSS for the Macintosh, and anyone can do it.

IPSS is a flexible population-analysis and projection-modeling program that does everything that my old models ever dreamed of doing and more, and does it without fuss or bother. It makes extensive use of the Mac interface for data input and output. It's intuitive to use.

In a word, if you're interested in projecting population data, such as how many female teenagers will be in my state in six years, or how many mature workers will be in the U.S. in the year

continued

ITEMS DISCUSSED

CPP126 .... $56.95
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Scotts Valley, CA 95066
(800) 877-7844
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Inquiry 989.

DESQview/386 .... $189.90
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Inquiry 990.

Interactive Population Statistical System
for Mac Plus $295
for Mac II $395
PSRC Software
Population and Society Research Center
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Bowling Green State University
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Solon, OH 44139
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Inquiry 997.

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Taesung Industries, Inc.
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Alpharetta, GA 30201
(404) 664-8944
Inquiry 998.

WingZ $399
Informix Co.
16011 College Blvd.
Lenexa, Kansas 66219
(913) 599-7314
Inquiry 999.

2005, or how many females of an age to use cosmetics will be in the state of Washington in 1996, you need this program. People who make business plans (and need to predict the customer base); school boards; all kinds of people can use this thing, although they probably won't.

IPSS is a powerful tool, and it will take you a while to master it. No matter. You can begin playing around with it minutes after you load it. The manual is extraordinarily complete—there's even a listing of the Pascal source code of the program—with a complete explanation of the assumptions made in the model. It happens that I don't agree with all of them, but that's mostly a matter of omission; and it's relatively simple to take the output of the IPSS model and use that as the input for my own models if I really want to do that.

Mostly, though, I just want to play with this. It's elegant, easy to use, and useful. If you have any interest in population, get this for your Mac.

Highly recommended.

Spreadsheet Wars and System Wars

Lotus 1-2-3 release 1.0 was a phenomenon. You can make a good case that this program moved the IBM PC from a home and hobby machine to the business world, simultaneously blowing Apple II and VisiCalc out of offices and off to the periphery of the computer industry. Software developers—big outfits and garage start-ups alike—have been trying to wedge into the Lotus 1-2-3 market ever since.

The only one that had much success was Microsoft's Excel, which did for the Mac what Lotus had done for the IBM PC: make it a serious contender for business offices. Excel was a completely different kind of spreadsheet, one that incorporated graphics, analyses, and an easy-to-use macro programming language, all features that both VisiCalc and Lotus 1-2-3 release 1.0 lacked. Prior to Excel, the Mac was an interesting little machine, useful for graphic artists, perhaps, great for games, and satisfactory—but no more than that—as a word processor. For real business work, though, you needed a PC and Lotus 1-2-3 until Excel came along; after that, the advantage in power lay with the Mac.

Excel had another effect: by showing just what the Mac could do, it generated a whole slew of powerful programs linking forms generation and the spreadsheet concept. The best known of those was MacInTax, but there are plenty of others. Even with all that, Excel and the Mac still have a relatively small market share, about 15 percent; but that's still not only respectable, but the largest single rival to Lotus 1-2-3 (with a 70+ percent share) in the spreadsheet market.

This situation seems fairly stable, too, which is interesting, because there are now considerably more powerful spreadsheets than either Lotus 1-2-3 or Excel. Apparently they aren't *enough* more powerful to tempt Excel and Lotus 1-2-3 users to make the change.

I can understand that. I don't have a great deal of spreadsheet work, but when I have some to do, I use SuperCalc. This is largely for historical reasons: I've known its authors Richard Frank and Paul McQuesten since they developed one of the first CP/M Pascal compilers, so SuperCalc was the first spreadsheet I tried. I didn't care for Lotus 1-2-3 when it came out because for years it was copy-protected, and I've always believed that anyone who trusts business affairs to copy-protected software ought to have a really good knowledge of the Chapter 11 bankruptcy laws. By the time Lotus came out with an unprotected version, I was up to SuperCalc 3 and was used to it.

I was also used to its limitations, and thus I wasn't tempted to demand of it anything it couldn't do. Indeed, I got so set in my ways that when SuperCalc 5

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arrived a few weeks ago, I didn't bother to install it—and I still haven't. I should, of course, but there's no urgency. I can't think of anything I want to do that I can't do now.

It's much the same with Borland Quattro, both the old standard and the new Quattro Pro. I know Quattro Pro is more powerful than Lotus 1-2-3 and SuperCalc, and easier to use to boot. I know very well that if I were starting over, about to set up a spreadsheet for the first time, I'd very likely use Quattro Pro. I'd want to do a playoff between Quattro Pro, SuperCalc 5, Lotus 1-2-3 release 3.0, and Excel 2.2; but from the limited experience I've had with all those, I'm convinced I'd choose Quattro Pro.

Meanwhile, back at the Mac front, it's much the same story. While I do all my financial spreadsheet work on PCompatibles with SuperCalc 3, when I do scientific modeling using a spreadsheet, it's always Excel on the Mac IIx. That's also partly historical—Dr. Michael Hyson did the first I/O model of a lunar colony with Excel on the Mac, and that's still the most elaborate model available. It's also just plain easier to do elaborate spreadsheets in Excel on the Mac, and if you ask why I haven't long ago abandoned PC spreadsheets entirely and moved my financial operations to the Mac, I haven't got a good answer. Partly it's printers. The PC uses my ancient Hewlett-Packard LaserJet Plus, which warms up faster than the Apple LaserWriter. Mostly it's just inertia and sloth.

More to the point, though: Excel is not, in my judgment, the best of the Mac spreadsheets. Informix Software's WingZ is newer and more useful. But for the same reason that I haven't converted from SuperCalc 3 on the PC, I haven't changed from Excel to WingZ on the Mac. What I've got is good enough, meaning that I have no choice but to live with the limits of what I have.

It should be fairly clear, then, that you shouldn't do as I do. If you're just getting into the spreadsheet business, you don't want SuperCalc 3 for the PC: you want to have Quattro Pro. If you're a Mac user, there's nothing *wrong* with Excel, but WingZ is a considerable advance beyond it and easier to learn in the bargain.

I found that out watching Frank, my number two son, who graduated with a degree in business administration this summer and is now going into telephone communications services. He's grown up in a house full of computers, so they neither intimidate nor fascinate him. They're just tools. He had an AT with Framework while he was in college. He also had SuperCalc and most of the programs I use. And when I asked him what he wanted to get set up and started in business, he didn't even hesitate. He wants a Mac IIcx with WingZ, Microsoft Works, and Ready-Set-Go!; and he can do things with WingZ that I never even thought of trying with Excel.

Stewart Alsop concluded that the only way that millions of satisfied users can be wooed away from Lotus 1-2-3 release 2.01 is through adoption of radically new systems, either software or hardware. Windows might do it, or Presentation Manager, or a radical shift from the PC to the Mac; but unless something like that happens, users will go on with what they have on the theory that good enough is good enough, and if it ain't broke don't fix it.

There's a lot of inertia in the user community.

The moral of my story is simple: if you're just beginning to learn about small computers for business, don't select your software purely on the basis of what everyone else is using. Look around. There's probably something better.

DESQview Pains

Roberta always gets my older-model computers. She says she doesn't mind. The other day I noticed what she was running: the Kaypro 386i, one of the first 80386 machines ever to come out. It had only 512K bytes on the motherboard; you used Quarterdeck's QEMM-386 to backfill the system memory to 1 megabyte with some of the 2 megabytes of extended memory that came with it.

Kaypro shipped the machine with DESQview, and, indeed, the 386i with DESQview was about as good as any 80386 computer on the market in its day; but that was a couple of years ago. The machine is slow, it has only one floppy disk drive (and that's getting flaky), and there's only a 20-megabyte hard disk drive. Roberta has long since filled it and keeps having to peel stuff off to floppy disks. It's clearly time to set her up with a new system.

I knew just the machine. The Zenith Z-386/15 has a 70-megabyte hard disk drive, and it's twice as fast as the Kaypro, is just as reliable (but no more so: except for that flaky floppy disk drive, we haven't had any glitches at all from the Kaypro, and we've used it *hard*), and, best of all, has both 1.2-megabyte high-density and 360K-byte standard-density 5¼-inch floppy disk drives.

Indeed, Roberta has been using the

continued

Z-386/15's standard-density floppy disk drive to make the shipping copies of Mrs. Pournelle's Reading Program, which uses a PC to teach anyone from age 4 to 104 to read English (see "Language Sojourn," April). At the moment, the Z-386/15 has the 19-inch Electrohome monitor running off Video Seven's fast RAM VGA board, so it's a lovely thing to see, just right for demonstrating stuff.

Its only problem is that I had never set it up properly with DESQview, and, like me, Roberta is used to DESQview's convenience.

DESQview lets your 80386 system run programs from extended memory. They aren't swapped in and out; they're actually run from high memory. This is possible only with an 80386; with 80286 ATs and 8088 XTs, you can use that memory for fast swapping, but you can't run the programs up there. The trick, then, is to configure your 80386 so that you get large—520K bytes and larger—windows in DESQview so that you can run TSR programs like WordFinder in the same window with your word processor.

This is done on an 80386 with Quarterdeck's QEMM-386 memory manager, which not only lets you make use of memory above 1 megabyte, but also lets you do special things with the memory between 640K bytes and 1 megabyte if you use the RAM switch in the QEMM command line. Thus, if you include the line DEVICE = QEMM.SYS RAM ROM in your CONFIG.SYS, you can use a Quarterdeck program called LOADHI.COM to put things like mouse drivers and buffers, which now run in ordinary system memory, up in the 640K-byte to 1-megabyte extended-memory area. (They won't go into the area above 1 megabyte without being specially written to do that, and most such drivers haven't been.)

The ROM command "shadows" or copies your ROM BIOS into high RAM memory, speeding things up a lot.

In other words, QEMM improves your 80386 even if you don't use DESQview. My problem was that I couldn't get the Z-386/15 to use QEMM properly.

The first thing was to eliminate the ROM command. Zenith more or less invented the trick of shadowing ROM into RAM. They call it Slushware. If you have QEMM do it also, you get conflicts. If there's a way to turn off the Slushware feature, I can't find it in the setup program or the manuals. OK, no ROM command, since it's not needed anyway. Alas, the system still blew up and had to be booted from a floppy disk so that I could edit the CONFIG.SYS file. Sigh. I was used to that: but let me warn you, before you start experimenting with CONFIG.SYS, make up a boot floppy disk and keep it handy. You will probably need it.

The next thing was to put DEVICE =QEMM.SYS into CONFIG.SYS without the RAM statement. That booted fine. Then I ran the program QEMM.COM. This shows a memory map of the Z-386/15,

A000–AFFF Video
B800–B7FF Mappable
C000–C5FF ROM
C600–C7FF RAMmable
C800–DFFF Mappable
E000–EFFF Page frame
F000–FFFF ROM

which told me what I had to do: I needed to use the command line DEVICE= QEMM.SYS RAM X=A000-AFFF X=B000-B7FF X=B800-C5FF X= F000-FFFF. This excludes those memory areas so that QEMM doesn't try to take charge of them.

Next, invoke DESQview through the program XDV.COM, which loads the main program DV.EXE partly into the 640K-byte to 1-megabyte extended-memory area and partly into the area above 1 megabyte. (Most people rename XDV.COM to DV.COM; then when you enter the command DV, DOS chooses the communications program to run first.) The result was that even after loading the mouse driver into high memory (the command is either LOADHI.SYS MOUSE.SYS in CONFIG.SYS or LOADHI MOUSE 2 in AUTOEXEC.BAT), I got windows with 572K bytes—pretty respectable. Without DESQview, I had DOS free memory of just under 600K bytes, and you don't hardly get no better than that.

Once I had the Z-386/15 running properly, I figured it would be no trick to do the same for the new Z-386/25. This machine is awesomely fast. It comes with the usual Zenith wonders, like their built-in Monitor (not hardware: a program that manages the system for you) and, best of all, the new Zenith DOS 3.3 Plus, which has nearly all the features of DOS 4.01 without the drawbacks. As an example, Zenith DOS 3.3 Plus allows the Z-386/25's hard disk drive to be configured as one single logical drive of 155 megabytes. One warning about the Z-386/25: any memory above the standard 640K bytes has to come from Zenith. Cheetah cards, although fast enough, won't work; the Z-386/25 never finds the memory. Instead, you must buy single in-line memory modules. There's room for a lot, 16 megabytes or more.

The Z-386/25 is clearly faster than my present Cheetah 386, and since I generally try to use the latest and greatest, it was a candidate to be the main machine here at Chaos Manor. To do that, though, it would have to run big DESQview windows; but that shouldn't be a problem now that I had set up the Z-386/15.

I connected the two machines with the new six-headed cable supplied by Traveling Software and invoked LapLink 3 on the Z-386/15. There wasn't a copy on the Z-386/25, but no matter: LapLink 3 will send itself to the other machine. Once I had the two Zeniths linked, I transferred a number of files from the old Zenith to the new one, including the CONFIG.SYS and AUTOEXEC.BAT that set QEMM-386 up properly. Now to reset the Z-386/25.

No joy. It locked up, and I had to reboot it with a floppy disk.

Sigh. What now? I could only guess: I changed it from X=B800-C5FF to X=B800-C7FF, thus excluding that small area that QEMM had called "RAMmable." Booted again. The machine came up fine. Now to load DESQview using XDV.COM. Again, no joy. The machine locked tight and had to be booted with a floppy disk.

This was getting annoying. DESQview loaded without XDV worked all right, but the maximum-size window was under 400K bytes, and that just isn't enough. Why would it blow up when I used XDV? I had no clue, but I did have a hunch. The Z-386/25 was running the Zenith Flat Technology Monitor (FTM) with a VGA board that read "Made in Hong Kong" but otherwise had no indication of the manufacturer. Could this be the problem?

Enter Tecmar

I have had a Tecmar VGA video board around for a long time, but we couldn't get it to work. It wasn't the board's fault: when we tried to install it in Big Cheetah, I was still using the Electrohome 19-inch monitor at my own workstation, and, at the time, that had a cable ending in a 9-pin plug: the Tecmar board wants to feed a 15-pin VGA connector. Then there was some other logistic problem, again not the Tecmar board's fault. "Time, and time enough," I thought. "Test my hypothesis about what's making XDV.COM blow up the Z-386/25 and give the Tecmar board a workout in the bargain."

Installing the Tecmar board was no

problem; the switch settings are explained in the manual. The Z-386/25 came right up. I thought the on-screen characters looked a little distorted, and in general I wasn't happy with the aesthetics of the screen, but what the heck, maybe it needed some tweaking. First, though, the test.

XDV.COM loaded. DESQview came up fine. The memory status utility told me I could make a window 550K bytes in size.

Clearly my hypothesis was correct. It was the video board.

Tweaking the Tecmar

So that problem was solved, but I still had an ugly screen. It might not have been so noticeable on some other system, but on the Zenith FTM every flaw in the video stands out because the FTM is capable of really beautiful displays. Moreover, because that monitor screen is truly flat, there is almost no glare from the screen itself. That's the main reason I changed from the Electrohome monitor: my workstation is across the room from a large south-facing window, and in the afternoon the glare on the screen can be fierce unless I draw lightproof blinds. I don't *want* to draw blinds; south of me are undeveloped hills with coyotes and circling hawks, and I like the view out that window. With the Zenith FTM, I don't have to give up hawk-watching to avoid glare.

The Tecmar board is capable of supporting a whole bunch of monitors. You tell it which ones you're using through software: a program called VGA.COM does the job. It can be run interactively, so I tried that. One of the program's options is to test the hardware: running this produced considerable garbage on the screen, making me suspect that the Tecmar board and the FTM weren't communicating properly.

VGA.COM has a list of monitors the Tecmar board can support. One was "Zenith Analog," which seemed a reasonable choice but wasn't. The display was *much* worse, fuzzy and unfocused. Another option was "IBM PS/2." For some reason I tried that—and it worked perfectly.

I now have the command line "VGA PS/2" in the Z-386/25's AUTOEXEC.BAT file, and it does the job something wonderful. The combination of the Tecmar board and the Zenith FTM is about the nicest I have ever seen outside MIT's laboratories. It's truly lovely, and *fast* to boot.

Highly recommended. This thing is

continued

gorgeous. You ought to see what it can do with VGA Paint from RIX SoftWorks.

A General Ledger

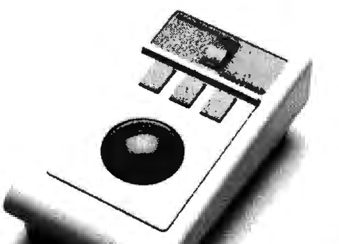
The shareware of the month is PC General Ledger from Charter Software, which does in fact produce a pretty standard general ledger bookkeeping system. It's menu-driven and very easy to use. I still prefer the system I wrote, but then I'm used to mine. I'll say this, if I'd had this program, I might not have written the one that I now use.

Starting this month, the shareware of the month can be found in the "listings" area of the tojerry conference on BIX. Download it and try it.

Gadgets

Gadget lover that I am, I have decided to have a gadget of the month, which this month goes to the Dali Design PT-1.2 pocket tester. This is a tiny thing that you plug into your auto engine's test outlet and read off all kinds of diagnostics. It works on Ford EEC IV systems from 1984 and later, which includes my 1987 Bronco II (which, incidentally, I love; best four-wheel drive vehicle I ever had, and that includes the International Scout I drove for 15 years).

For another $20, they'll send you a book on repair procedures, trouble codes, and so on. If the electronics in your Ford bewilder you, this is the thing to have; my mechanic *loves* it.



Winding Down

There's a huge pile of stuff here. We have Palindrome, a tape backup unit that's so versatile I'm stunned; it will be the mainstay of our new network system here.

We have new USRobotics 19,200-bps modems. These include the MNP (ARQ) error-correction protocols used by MCI Mail, BIX direct (alas, not Tymnet), GE's GEnie, and a number of other telecommunications systems. More on this next month—but if you do much telecommunications, get the latest MNP modem and forget about line-noise problems. The improvement in throughput is amazing. I love these things. We've discarded all modems but USRobotics models.

The game of the month is Sword of Aragon from Strategic Simulations. This is a medieval warfare game with some fantasy role-playing elements, but mostly it's strategy in the age of bows and swords. The only way to win is to develop and deploy combined-arms armies. I cannot remember when I have more enjoyed a computer war game.

The book of the month is *Mazes: Sixty-Four Essays* by Hugh Kenner (North Point Press, 1989), who happens to be BYTE's book reviewer and one amusing writer. There's not a bad essay in the bunch. Try it, you'll like it.

There's a lot more, but I'm out of space, and besides, my army is assembled outside Garnok, the high mountain pass fortress of the orcs, and I've got to put my heavy cavalry in the right place to deliver the decisive charge.... ■

Jerry Pournelle holds a doctorate in psychology and is a science fiction writer who also earns a comfortable living writing about computers present and future. Jerry welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply. You can also contact him on BIX as "jerryp."

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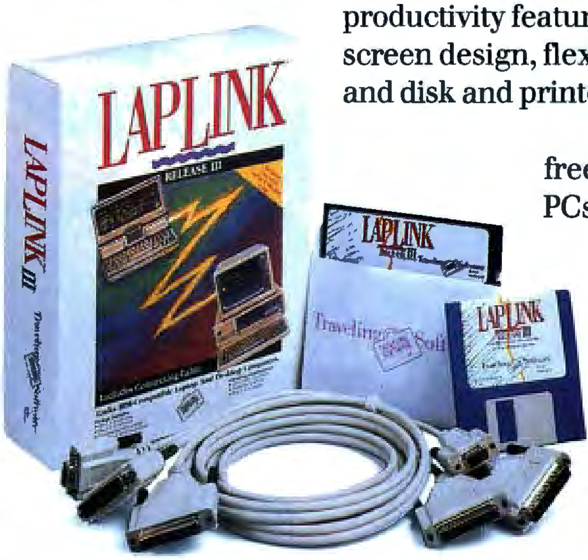

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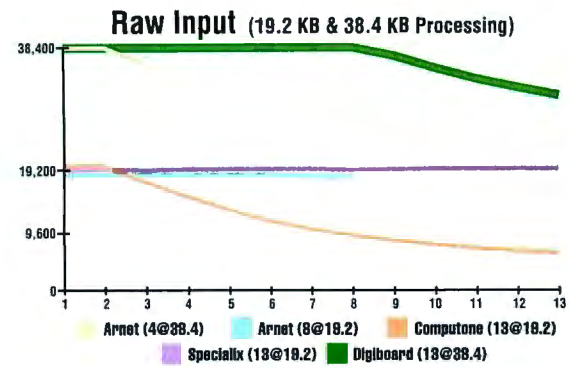
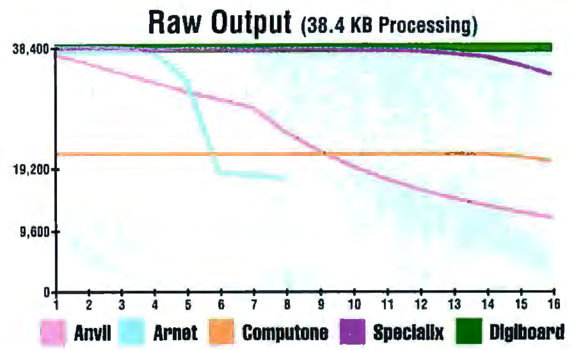


Raw Input: Primarily data received via host-to-host communications. The higher the better.



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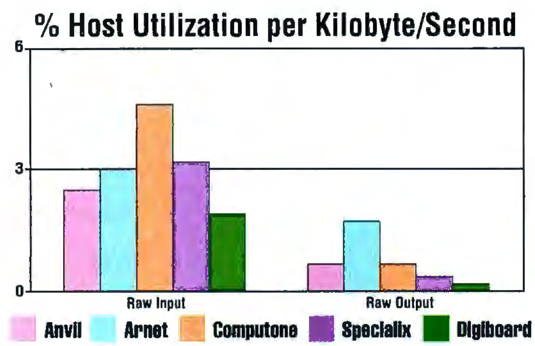
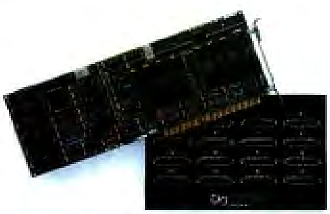


Processor Overhead: Percentage of host CPU time utilized for I/O processing tasks. The lower the better.



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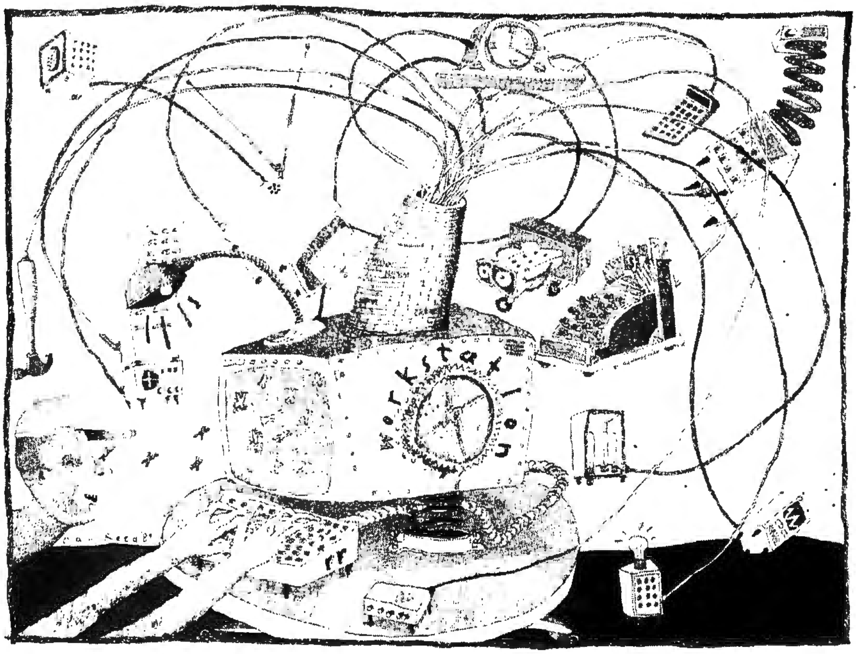
UNIX WORKSTATIONS CONNECT

If Unix is multiuser, why would you want a Unix LAN?



As new and faster processors reach the computer industry, more powerful computers become accessible to end users. This is a familiar refrain in magazine articles about personal computers. It's even more applicable to Unix workstations, where new technology is dramatically dropping prices to personal computer levels. You might be thinking about adding an Ethernet port to your microcomputer. . . or even running out and buying a workstation! Now is the time to talk about networks and workstations.

What's a Workstation?

Almost anything with more CPU power than a toaster is being called a workstation these days. But my idea of a workstation is a computer with a high-resolution graphics display running a multitasking operating system and window management software, specifically designed to operate on a network. Any workstation worthy of the name would also have an Ethernet port and a mouse.

This definition rules out a PC with an Ethernet card—it's just a PC with the *ability* to use a network. The Macintosh comes a little bit closer, but it's really been designed to be a stand-alone machine. A high-resolution terminal designed around an Ethernet connection doesn't qualify—it's not a computer. Some Macs and PCs have been specially configured to use a network. If they have high-resolution screens and multitasking window managers, then they could actually be workstations by my definition.

The key to having workstations is similar to that of eating potato chips: Nobody has just one. A single diskless workstation is useless without a file server (basically just a computer with a lot of disk space). File servers are too expensive to dedicate to a single workstation. But add just one more diskless workstation to your first node and server, and you have a network. The cost of adding workstations is relatively low, considering the amount of additional computing power they give you.

How They Work

A network of workstations is comparable to a multiuser computer system. In the old-style "timesharing" setting, you bought a computer with a multiuser operating system, such as Unix, and connected dumb terminals to it, using serial connections at perhaps 9600 bps (roughly 1000 bytes per second).

On a workstation network, the central computer (or file server) generally also runs Unix, but it tends to have more disk storage than the usual departmental computer. The workstations, instead of being simple terminals, are computers running Unix themselves. Typically, they connect to the server through Ethernet. They communicate at 10 megabits per second (roughly 1 megabyte per second) using TCP/IP protocols. TCP/IP is the de facto industry standard for Unix networking, but it is also the basis for networks on other operating systems (see "The Glue for Internetworking" in the LAN Supplement, September BYTE).

How can a diskless workstation boot up Unix without a disk? The basic startup software is in ROM. When the workstation is powered up, the ROM-based software identifies itself to the file server and requests a file transfer (of the Unix kernel) to its local RAM storage. From then on, you're working with the network, running Unix locally and transferring files transparently as needed—at speeds higher than those of typical PC hard disk drives. And since each workstation on a network is itself a computer,

continued

ILLUSTRATION: DAN REED © 1989

running a compute-bound task on one node won't slow the others down.

Not Your Ordinary PC

The bare minimum workstation, then, is entirely diskless. The most inexpensive one I am aware of is the Sony NWS-711. It is based on a Motorola 68020 CPU and a 68881 FPU, both running at 16.67 MHz, for a claimed 2.3-million-instruction-per-second processing power. It has 4 megabytes of memory and a 15-inch monochrome monitor with 816- by 1024-pixel resolution (it's a "portrait mode" monitor; the screen is configured like a vertical sheet of paper). The 711 lists for just $3700, which includes Unix as well as C, Pascal, and FORTRAN compilers.

Apart from being a diskless workstation, the 711 can also be used as an X Window terminal. In fact, since it has no disk, it *looks* like a graphics terminal, but, of course, it is much more powerful. (For more information, contact Sony Microsystems Co., 1049 Elwell Court, Palo Alto, CA 94303, (415) 965-4492.)

In compute-happy environments, such as semiconductor design, you might see a *dataless* workstation. It has its own disk drive—up to 180 megabytes—but, since so much system software and swap space is needed on the disk, all applications and user files reside on the server. The local disk drive merely keeps the system going by keeping memory paging local.

X Marks the Spot

Ethernet and TCP/IP are the low-level links common to most Unix networks, and the X Window System is the common base for user and application programs. X Window (as it is almost universally called) was developed at MIT with assistance and support from Digital Equipment Corp. (DEC) and IBM. It's not public domain code, but it is publicly available and free for the asking.

Because TCP/IP is a set of network protocols that are transparent to the operating system, X Window is a network-transparent windowing system. This has several meanings, all of them good. X Window is not tied to any given network protocols, so it is just as happy running on DECnet as it is on TCP/IP. This means you can run applications on any machine on your network and control them all from individual windows on your terminal. Note that I said "machines," not "Unix machines." They don't all have to be made by the same manufacturer, or even have to be running the same operating system. They just have to be in your network and running X Window.

continued

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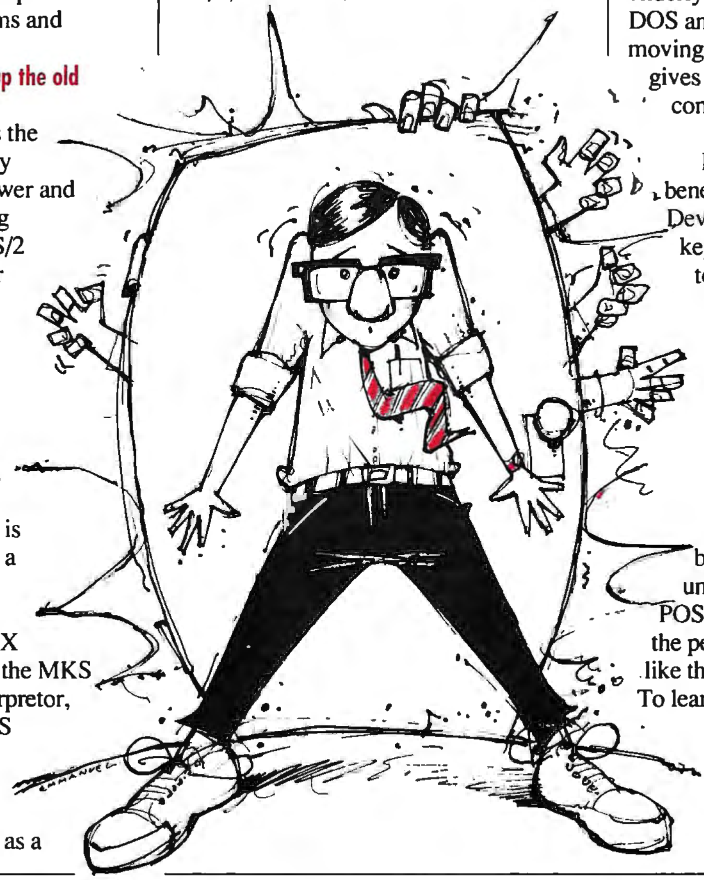

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X Window is pretty much hardware-independent at the user's graphical-display end. This means that if you're running an application on a vertical-screen monochrome display this week, you can run it on a horizontal-screen 24-bit color workstation next week with no problems. What all this means is that companies can now design their computing environments around their users' needs, not around the current offerings of a particular manufacturer. The phrase "heterogeneous network" is usually used here by industry reporters, although it sounds too clinical for my taste.

Getting GUI

Although many people are happy to run `xterm`, the X Window Unix-compatible terminal emulator, X Window is not really a graphical user interface. It does make a terrific basis for one, however, and any GUI written to run on X Window will be highly portable as a result. This is the theory behind the current industry struggle between Open Look (a GUI promoted by Sun, AT&T, and Unix International [UI]) and Motif (promoted by the Open Software Foundation [OSF]). Both of these will be available widely and inexpensively, to the ultimate benefit of users. Of course, every layer of software that you add increases not only your productivity but also your system's complexity and its need for additional disk space and CPU power. But then, that's part of the game: If you want to work with the state of the art, you're going to have to pay for it.

If you don't want to get caught between OSF and UI, you might want to look into X.Desktop, a Macintosh-like, icon-based X Window user interface from IXI Ltd. of Cambridge, England (see the text box "Managing the X Window Desktop," January BYTE, page 356). X.Desktop is an intuitive interface that lets you bypass many typical Unix system commands; it will support both Motif and Open Look styles in the future. It can be obtained in the U.S. from Unipress Software (Edison, NJ). X.Desktop has been adopted by companies such as Locus Computing, Motorola, NCR, Uniplex, and The Santa Cruz Operation (which is including X.Desktop as part of its Open Desktop product).

In fact, if you really get hooked on X Window and don't have a network, you can still run X Window applications on a single machine. The system simply uses Unix interprocess communications instead of network protocols—more proof that programmers are truly happiest when they're talking to themselves.

You Also Need Files

So you have portable industry-standard protocols, windowing, and user interfaces. What's left? How about a way of hooking networked machines together so that you can not only transfer files, but mount an entire file system from a remote machine onto your local workstation and access it transparently? That's the Network File System, developed at Sun Microsystems in 1984 (not at Berkeley, as I mistakenly wrote in BYTE in May). NFS generally uses UDP/IP, a faster (but technically less reliable) set of protocols than TCP/IP.

NFS, like X Window, is portable and publicly available, as well as user- and protocol-transparent. By now, you can guess what's coming: "These factors have led to its becoming an industry standard." And, as a standard, NFS is another piece of software that is found on almost every Unix network. Since users no longer have to worry about where their files reside, it's only the administrators who have headaches. (Just keeping track of user log-ins and machines on a network can be a major task.)

The real beauty of NFS is that it is *not* tied irrevocably to Unix. In fact, machines running MS-DOS, VMS, and IBM VM have all been placed happily in NFS networks, as with X Window. Getting these disparate systems to share files transparently is a magic trick, indeed. By comparison, LANs that work only with DOS machines and nothing else don't seem very sophisticated at all.

Since the Unix kernel itself is just another file, there's no reason why a diskless Sun workstation couldn't boot up by requesting its kernel file from a DEC server. And, in fact, this kind of thing happens every day. This shows the essential nature of today's networks: They stand apart from any quibbling over "small" details like machine architecture, byte ordering, the operating system, or even the network protocols themselves. A properly designed industry-standard network will simply accept any and all of these, so that users can have their favorite hardware as well as their favorite software. After all, making users happy is the name of the game! ■

David Fiedler is publisher of the Unix Video Quarterly *and the journal* Root, *and is coauthor of the book* Unix System Administration. *He can be reached on BIX as "fiedler."*

Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

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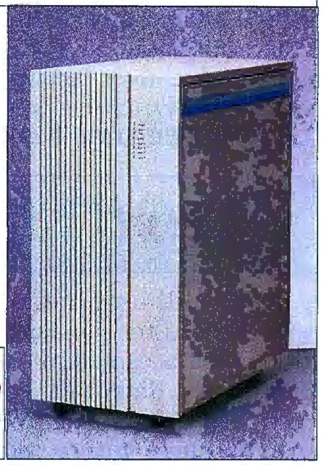

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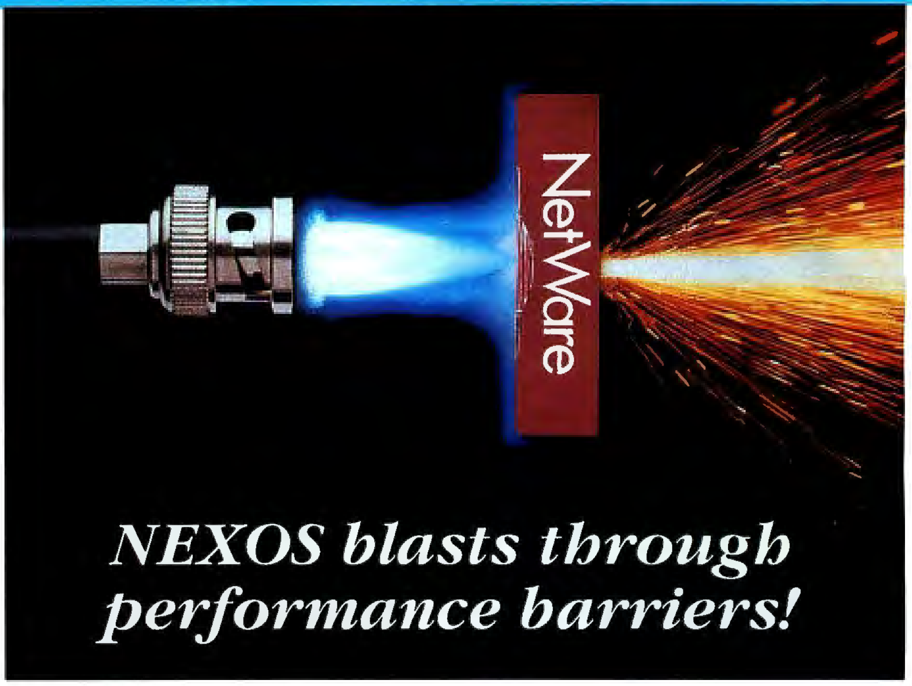

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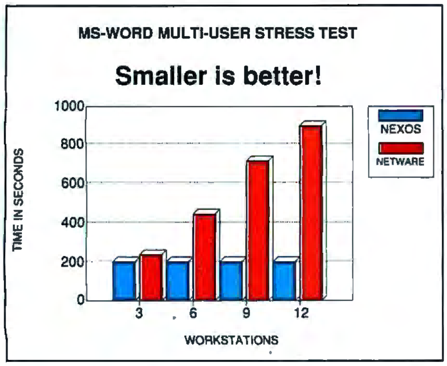

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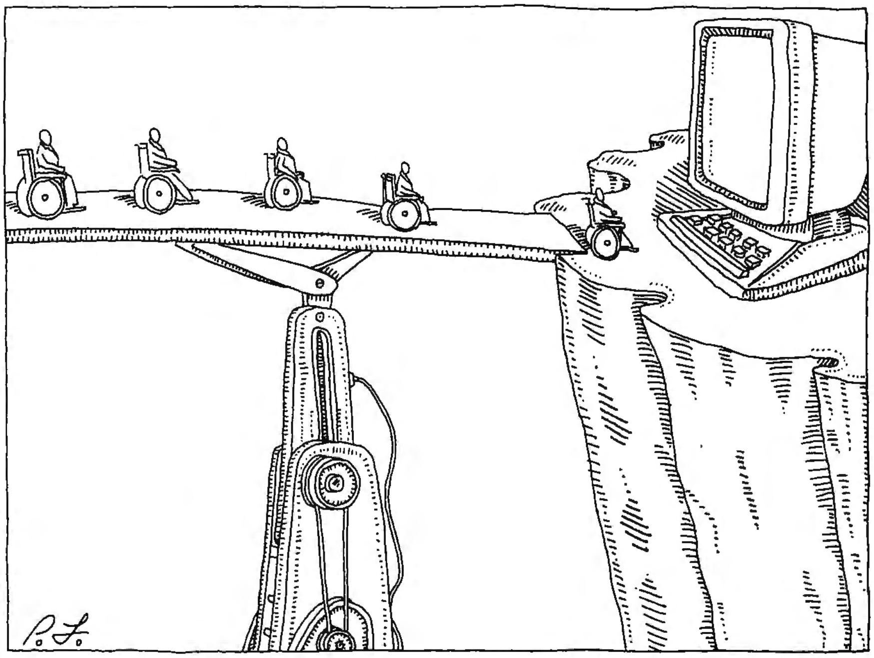
A HELPING HAND

A new workstation lets physically challenged people take their place in the high-tech workplace



When small computers first came on the market 15 years ago, they looked like a real boon for handicapped people. Combine machine intelligence, voice control, and a robotic arm, and you've got a way to give disabled people enhanced independence and a greater opportunity to be productive. Handicapped people weren't the only expected beneficiaries of such a system, either. Faced with skilled-labor shortages and federal legislation requiring equal opportunity for the physically challenged, businesses all over the country have been looking for ways to put physically disabled people in front of computers.

But the reality has been a long time coming. The problem is that most of the solutions, including speech-recognition systems and robotic arms, are stand-alone peripherals. You have to do your own system integration, and most businesses don't have the time or the personnel for that. What the industry needed was a prepackaged, integrated solution that would work well, satisfy requirements, and meet the needs of both the employee and the business.

The fact that handicapped people have been bypassed has become a significant problem for many businesses. There are two reasons for this. First, in many areas of significant technological growth, there is also an equally significant labor shortage. Second, the federal government has mandated that facilities must be provided to give handicapped employees a fair chance at doing work.

Employing the handicapped is not much of a problem in some businesses. But in others, hiring people with certain handicaps presents a serious problem. To be productive using computers, for example, you have to be able to type. The problem is that many physically handicapped people have limited use of their hands and arms; otherwise, they are perfectly capable of performing work. They just need a way to perform it.

Now Zenith Data Systems, through its Heath subsidiary, and Prab Robotics, through its Prab Command subsidiary, have delivered a workable solution at a reasonable price. It allows the user to perform any required function on a personal computer through the use of voice commands alone.

Included in the Prab Voice Command I package are a Zenith Z-286 LP computer and Zenith's FTM flat-tension monitor, a voice-control keyboard designed by Prab, a robotic arm (also designed by Prab), a Hewlett-Packard LaserJet II printer, a telephone system, and a specially designed work area. It retails for $49,500.

The robotic arm looks like an industrial robot, but it is specifically designed for this application and incorporates a number of safety features to ensure that a user would never be hurt by it. The arm can move objects near the desk and handle paper from the printer. It can even remove a soda from a refrigerator.

The voice command system is the star of the workstation, though. I sat next to Jan Ziff of the British Broadcasting Corporation in the Alexandria, Virginia, Heath/Zenith store and watched while she issued orders to the computer in her best BBC broadcaster's voice. A square on the screen followed her commands. "Up, down, left, right, stop," she said. The square on the screen went up, down, left, right, and stopped. "Exit," she said. A menu returned to the screen.

A few minutes later, I gave the same

continued

commands in a mixture of Russian and Spanish, both tinged with a faint hint of Virginia. The square on the screen followed my every order. Then Jan's orders turned to controlling applications on the screen, and finally running the robotic arm. The computer performed without a hitch.

The Sum of Its Parts

The Heath/Zenith-Prab collaboration succeeds where other systems have failed because of the attention that both companies pay to details when it comes to integration. It's clear from the results that a considerable amount of testing has gone into the design and assembly of this product. In short, it works well, even for users unfamiliar with it, such as Jan Ziff and me. We were able to train it to our voices and start work in minutes.

It helps that the components that make up the workstation are carefully crafted to work together. The Zenith Z-286 LP is a fast, 80286-based IBM PC AT-compatible computer. It supports Zenith's superb FTM monitor, an important asset for users who won't be able to adjust the tilt to avoid glare, since the FTM seems impervious to glare. Installed in the computer is Prab's telephone controller, and Prab's keyboard is attached.

The keyboard contains the voice-recognition system, which processes the commands before they ever get to the computer. The keyboard sends what appears to the computer to be a series of keystrokes. This is important because it means that modifications to the computer were not required to support voice recognition. Instead, another computer in the keyboard handles the voice. The Prab keyboard can recognize about 160 words. Those words can stand for individual keystrokes or for macros that can consist of hundreds of keystrokes.

The macro capability means that complex commands can be developed using only a word or two. According to Prab CEO Walter Weisel, users can run Lotus 1-2-3 faster with voice commands than with a keyboard. Weisel said that workers at Prab are able to run AutoCAD and make complex drawings using a collection of only 130 words.

Training the voice-recognition system takes only minutes. The training program takes you through the basics of the keyboard, asking you to pronounce each word displayed. After you've done this two or three times, the software decides that you are trained and stores the vocabulary on the hard disk drive. From that point on, you can operate the computer entirely by voice.

ITEMS DISCUSSED

Prab Voice Command I .. $49,500
Heath/Zenith
Prab Command
5140 Sprinkle Rd.
Kalamazoo, MI 49002
(616) 383-4400
Inquiry 1079.

Voice Command II $21,900
Heath/Zenith
P.O. Box 377
St. Joseph, MI 49085
(616) 982-3341
Inquiry 1078.

Independence

There's more to independence than running a computer, whether you're in an office or at home. For this reason, the package includes a phone management system that lets the user make or receive calls. Like the rest of the workstation, it operates under voice control.

I watched as Heath Area Manager Bob O'Neill spoke the instructions to make a phone call. "Special down," he said into his headset. The menu bar on the main menu moved down one place. "Down," he said again, and "return." The menu bar moved down another place, and then the Telephone Management choice was selected. "Return," he said again. The computer asked what number was to be dialed. "Digit one six one six three eight three four four zero zero, return," O'Neill said. The computer dialed the number for Prab Command.

In addition to allowing voice communications, the telephone-control system allows the computer to have modem communications. The operator can communicate with a mainframe to perform file transfers with other computers. According to Weisel, many users have taken advantage of this capability to trade voice-control macros and robotic-arm routines.

The workstation also contains an environmental controller that lets the operator control up to 250 X-10 devices. This gives users the capability to control lighting, appliances, and other electronic equipment. As a result, an assistant is much less necessary.

Modularity

The Heath/Zenith-Prab workstation is designed to be installed in the workplace in modules. A basic version, called the Voice Command II ($21,900), is available that has everything except the robotic arm, the laser printer, and the furniture. These items can be added later.

The furniture is an integral part of the design. It is built to exacting specifications so that every installation is the same. This is important, because users have indicated that they want to trade programming routines for the arm, and for this to work, everything needs to be in the same place. The workstation is mounted in a cubicle that is designed for wheelchair access. The desk height can be changed to meet the user's needs, and additional items, including refrigerators and microwave ovens, can be added.

Good Business

For the first time, a business no longer needs to be concerned with how it will make provisions for the requirements of a physically challenged employee. The Voice Command workstations enable such an employee to have the same capabilities and productivity as any other employee.

More important, these workstations do not require a massive infusion of capital costs or staff time to implement. They are provided off the shelf in a standard configuration. A business need only purchase the product. This finally places computing for the physically challenged employee within the means of most businesses.

Heath/Zenith eases the transition by providing both installation and training, which will include orienting the employee to the use of the equipment and training the workstation on the voice of the employee. Zenith has added to this package by providing reasonably priced leasing, bringing the workstation into a cost range that individuals can afford.

This product is clearly in the right place at the right time. The shortage of skilled employees has become critical. The government has mandated provisions for the handicapped. Heath/Zenith and Prab Command have provided the best answer so far.

There is, of course, one other reason. This is the best chance we've had for those we have left behind to be allowed to catch up. ■

Wayne Rash Jr. is a contributing editor for BYTE and a member of the professional staff of American Management Systems, Inc. (Arlington, VA). He consults with the federal government on microcomputers and communications. You can contact him on BIX as "waynerash," or in the to.wayne conference.

Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

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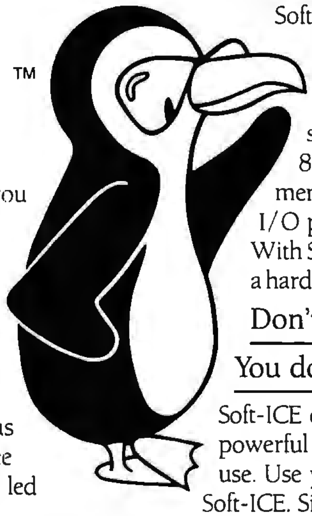

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OS/2 MULTITASKING REVISITED

A simple program that lets you experiment with the priority mechanism

Last month, I looked at how OS/2 manages multitasking, explained that programs get CPU time based on a two-level priority system consisting of *classes* and *deltas*, and mentioned that programs can set their own priorities. This month, I'll examine a simple OS/2 program that can be used to explore how OS/2 divides up time between processes.

When OS/2 came out, Rob Oreglia and I wrote the original version of the programs shown in listings 1 and 2. Listing 1 loads two child programs into the system, sets their priorities to whatever the user wants them to be, and lets them run for a while. When the child programs are done executing, they report what got done. The program with the higher priority should get more CPU time and therefore should get more done.

The main program, called PARENT, takes five parameters:

```
PARENT class1 delta1
class2 delta2 time
```

where `class1` and `delta1` refer to the desired priority class and delta for the first child program, `class2` and `delta2` refer to the same for the second child program, and `time` indicates how long to run the test. For example, executing

```
PARENT 2 0 1 31 30
```

would run the program for 30 seconds, setting the priority class (class is more important than delta, recall) of the first child program to 2 and the delta of that program to 0. The second child would get a class and delta of 1 and +31, respectively. The effect of this would be to run the first program at a higher priority than the second. Both programs would run, although the second would end up getting practically no CPU time. Remember that class 1 jobs always yield to class 2 jobs regardless of the deltas. A sample run might look like this:

```
Child 1: class=2 delta=0
Child 2: class=1 delta=31
Child 1 Executed with
return code=0 PID=178
Child 2 Executed with
return code=0 PID=179

Child 1 completed
100,486 iterations.
Child 2 completed 965
iterations.
```

The program echoes back what we've told it to do, reports that both children were successfully launched (`return code=0`), and reports their process IDs (PIDs). Every program started under OS/2 has a unique PID. This is necessary because you must have a program's PID to do anything to it (e.g., terminating it or changing its priority). You can't request to change the priority of, say, 123.EXE; you have to know its PID, and the PID varies from run to run.

The children then report how much work they got done (i.e., how many iterations they completed). Child 1, with the higher priority, got over 100,000 iterations done. Child 2 got only a small amount of time, finishing fewer than 1000 iterations.

You can use this program to compare different classes (1 = low, 3 = high) and deltas (−31 to +31). Some results for a 10-MHz zero-wait-state 80286 are found in table 1. I used `priority=dynamic`, `maxwait=1`, and `timeslice=256` in my CONFIG.SYS file under IBM OS/2 1.1.

How does it do it, and how can you run it on your system? You need just two

continued

ILLUSTRATION: ELIZABETH STUBBS © 1989

things: OS/2 and Microsoft's C Compiler 5.1. (If you haven't got that, the PARENT.EXE file is also available on BYTEnet or BIX.) Compiling the program is a piece of cake. You need the source code for the following programs: PARENT.C (listing 1), CHILD1.C (listing 2), and CHILD2.C. (CHILD2.C is not listed because the only difference between CHILD1 and CHILD2 is the message, "Child 1 [or 2] completed XXXXX iterations.")

When you installed the C Compiler 5.1, it asked you what subdirectory to put source code in; just put the three C programs there. Then compile them by typing `cl parent.c`, `cl child1.c`, and `cl child2.c`—no compiler switches are needed. Then you can run PARENT directly. If you type the source code in directly, be aware that case is important: `DosSleep(1000L)` will work fine, but `DOSSLEEP(1000L)` will not.

Listing 1: *PARENT.C, the main program.*

```
1  #define INCL_DOS
2  #include  <os2.h>
3
4  main(argc,argv)
5  int argc;
6  char * argv[];
7  {
8     RESULTCODES child_pid1, child_pid2;
9     int rc,duration,cpd1,cpd2;
10    unsigned mypriority,procid,cpl1,cpl2;
11    HSYSSEM stophandle,strthandle;
12
13  /* argument list:
14      1st = priority level child 1
15      2nd = priority delta child 1
16      3rd = priority level child 2
17      4th = priority delta child 2
18      5th = run time in seconds
19  */
20
21      if (argc != 6) {
22        printf("This requires five arguments, all integers.\n");
23        printf("First two are child process 1 priority class and");
24        printf(" delta,\n");
25        printf("third and fourth are priority class and delta for");
26        printf(" proc 2,\n");
27        printf("fifth is run duration in seconds.\n\n");
28        DosExit(1,255);
29      }
30
31      cpl1= atoi(argv[1]);
32      cpd1= atoi(argv[2]);
33      cpl2= atoi(argv[3]);
34      cpd2= atoi(argv[4]);
35      duration = atoi(argv[5]);
36      printf("Test will run for %d seconds.\n",duration);
37      printf("Child 1:  class=%d delta=%d\nChild 2: class=%d delta=%d\n",
38             cpl1,cpd1,cpl2,cpd2);
39
40  /* Now create, open, and set semaphores so children know when to stop */
41
42      rc=DosCreateSem(1,&strthandle,"\\sem\\start");
43      rc=DosOpenSem(&strthandle,"\\sem\\start");
44      rc=DosSemSet(strthandle);
45      rc=DosCreateSem(1,&stophandle,"\\sem\\stop");
46      rc=DosOpenSem(&stophandle,"\\sem\\stop");
47      rc=DosSemSet(stophandle);
48
49  /* Start the children */
50
51      rc=DosExecPgm((char *)0, 0, 2, (char *)0, (char *)0, &child_pid1,
52        "child1.exe");
53      rc=DosSetPrty(0,cpl1,cpd1,child_pid1.codeTerminate);
54      printf("Child 1 Executed with return code=%d
55             PID=%d\n",rc,child_pid1.codeTerminate);
56      rc=DosExecPgm((char *)0, 0, 2, (char *)0, (char *)0, &child_pid2,
57        "child2.exe");
58      rc=DosSetPrty(0,cpl2,cpd2,child_pid2.codeTerminate);
59      printf("Child 2 Executed with return code=%d PID=%d\n",
60             rc,child_pid2.codeTerminate);
61
62  /* Clear "start" semaphore so that the children can run */
63
64      rc=DosSemClear(strthandle);
65
66  /* Wait for prearranged time */
67
68      DosSleep(duration * 1000L);
69
70  /* Clear the "stop" semaphore so that the children will stop */
71
72      rc=DosSemClear(stophandle);
73
74  }
```

Lines 1 and 2 of PARENT.C obtain access to OS/2 header files and kernel functions. I'll be using kernel functions to start and control the child programs. Lines 4 through 7 are a C start-up boilerplate. Lines 8 through 11 define the variables. Two types are not standard C: RESULTCODES and HSYSSEM.

RESULTCODES is a 2-byte structure that receives the PID and returns code for a child process. When PARENT starts CHILD1, PARENT gets back the PID and (eventually) the return code for CHILD1. Ditto for CHILD2, so there are two structures. HSYSSEM is a system-defined type for *semaphore handles*. I'll get to them in a minute.

Lines 13 through 30 check that the user supplied the proper number of inputs. Lines 31 to 39 load these inputs into variables and report back to the user.

Next comes some code referring to the semaphores. Semaphores are flags used to control the execution of the children. Using a semaphore involves a semaphore handle. PARENT will create and take control of two semaphores that are called `start` and `stop`. (I could call them anything, but `start` and `stop` seem most descriptive.)

The children are then programmed to look for these semaphores. The way it works is simple: PARENT creates the semaphores and sets them, in lines 40 through 48. Notice that they're declared `\\sem\\start` and `\\sem\\stop`—all semaphore names must look as if they were filenames within a subdirectory named `sem\`. The \\ instead of \ makes C happy.

Now that the semaphores are created and set, it's time for the children. The children start up (lines 49 through 61 in listing 1 start the children) and first look to see if the `start` semaphore is set. Take a look at listing 2. Lines 11 and 12 in CHILD1.C open the semaphores, and line 16 waits for `start` to be cleared by the parent. PARENT clears that semaphore in line 64 of listing 1.

The children don't start counting how much time they get until `start` has been cleared, or unset. Then they count (lines 20 through 23 in listing 2) until `stop` is cleared. Meanwhile, remember the user-specified parameter `time`? In line 68, PARENT waits that many seconds before

continued

Listing 2: *CHILD.C, the subsidiary program.*

```
#define INCL_DOS
#include <os2.h>

main()
{
   long int iters;
   HSYSSEM stophandle,strthandle;

/* Set up semaphore */

    DosOpenSem(&stophandle,"\\sem\\stop");
    DosOpenSem(&strthandle,"\\sem\\start");

 /* Wait for parent to say it's OK to run */

    while (DosSemWait(strthandle,0L)!=0);

 /* Loop until semaphore clears */

    iters = 0;
    while (DosSemWait(stophandle,0L)!= 0) {
       iters = iters+1;
     }
     printf("\nChild 1 completed %ld iterations.\n",iters);

 }
```

Table 1: *Sample output from PARENT.EXE.*

SAMPLE OUTPUT FROM PARENT.EXE

Child 1			Child 2		
Class	**Delta**	**Iterations**	**Class**	**Delta**	**Iterations**
2	0	50,496	2	0	51,222
1	0	50,507	1	0	50,027
1	0	0	2	0	101,838
2	0	29,415	2	1	75,707
2	0	28,437	2	31	74,799
1	31	30	2	−31	100,789

Note: All tests ran in 30 seconds on a 10-MHz zero-wait-state 80286 running IBM OS/2 1.1.

clearing the stop semaphore in line 72. Then everything should stop nicely.

Lines 51 and 52 start up the CHILD-1.EXE program. Programs start up other programs with DOSEXECPGM, a hook into OS/2 (these hooks are called application programmer interfaces). DOSEXECPGM has a number of parameters, but I'm interested in only the last two for now. The penultimate one, &child-pid1, points to where DOSEXECPGM can leave the RESULTCODES structure. The last parameter, child-1.exe, is the program to load and execute. Line 53 changes CHILD1's priority once the child's PID is safely in hand. Lines 54 and 55 report how the whole operation turned out. Lines 56 through 60 do the same for the second child.

OS/2 Tip of the Month: Uppercase CONFIG.SYS

This one is thanks to Doug Hamilton. Members of BIX's ibm.os2 conference will often hear of strange results now and then from their OS/2s that can't be duplicated. One complains of format failures, another of crashed device drivers, and I experienced protection violations when XCOPYing in the background to a floppy disk. The answer was the same in all these cases: Make sure that your CONFIG.SYS entries are all in uppercase. I know, it's easier to read in lowercase, but apparently OS/2 doesn't think so. OS/2 1.2 will be out by the time you read this, and the problem may be fixed. But to be safe, use uppercase when possible. ■

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Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

A TALE OF TWO OPERATING SYSTEMS

A cross-examination of the features of the up-and-coming Mac and IBM PC operating systems

When you are considering the purchase of a microcomputer these days, it's both the best of times and the worst of times. The best, because never before have you had so many choices: You can pick and choose from a variety of powerful computer systems—IBM PC or Macintosh—and at prices less than a king's ransom. But this is bad simply because of the many choices: You can wander off into a swamp of details and options and disappear without a trace.

This month, I'll try to sort out some of these details for you. Since much of how a computer functions depends largely on the capabilities of its operating system, I'll focus on that. Coming under my scrutiny will be OS/2, the PC's premier operating system, and Apple's Mac OS.

One reason for looking at the operating systems is that when it comes to someone actually using a microcomputer, factors other than million instructions per second, million floating-point operations per second, Whetstones, Dhrystones, and other performance desiderata come into play.

I have nothing against performance, mind you. I'll take a faster machine any day. But in terms of office productivity, more computing power isn't the answer if a clerk has to run several different programs to transfer data from a spreadsheet to a charting program and then transfer this image to a word processing document. Office workers may be able to get through this intricate chain faster, but they have to know how to use each program first.

The Mac's big win here is that the office worker can simply cut and paste the chart from the charting application into the word processing document with just a few keystrokes. There's no need for format-translation programs or remembering special exceptions. You simply do it. You can concentrate on getting the job done, not fiddling with file formats in the computer. Isn't that what computers are supposed to do for you, anyway?

OS/2 is IBM and Microsoft's answer to the Mac. Although it can run existing DOS software in compatibility windows, OS/2 is a whole new system for 80286- and 80386-class PCs that includes graphical capabilities akin to those of the Mac through an interface called the Presentation Manager (PM).

Roots

The Mac OS is far older and far more advanced in its development than is OS/2 with PM. The Mac OS dates back to work done at Apple in 1980 and 1981. Preliminary efforts were implemented on the Lisa computer in 1983. The first released version of the Mac OS coincided with the introduction of the first Mac, in January 1984. Thus, it's six years old.

OS/2 didn't get started by Microsoft and IBM until 1986, although it's based partially on the Xenix and Windows products that Microsoft has been selling since 1984 and 1987, respectively. The first release of OS/2 didn't hit the market until 1987, and the PM wasn't released until 1988.

Because of its development lead and the much larger user base it has enjoyed, the Mac OS is a more refined product. In fact, the difference between using any Mac and an IBM PS/2 running OS/2 with PM is striking. Whereas the Mac works slickly and smoothly in its basic operations (e.g., file copying, renaming, folder management, and file deletion),

continued

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OS/2 does not. The Mac OS can run on machines with as little as 1 megabyte of RAM, although the new version, System 7.0, will require 2 megabytes. And it runs on all Macs, from the 68000-based Mac Plus, SE, and Portable on up to the 68030-based Mac IIci.

On a 1-megabyte Mac Plus, the current System (6.0.3) runs quite acceptably, even when you are using heavily graphics-intensive applications. A Mac Plus with a built-in high-resolution monochrome screen, an 800K-byte floppy disk drive, and an external 40-megabyte SCSI hard disk drive will set you back about $1500 at the deepest discounts available. Mac System software is distributed free of charge through dealers (although special printed documentation can be purchased).

OS/2 is not so refined. It feels clunky, especially its graphics interface. OS/2 with PM won't run on any PC with less than 3 megabytes of memory. It also won't run on any PC, XT, or compatible that's based on the older Intel 8088 or 8086 CPUs. OS/2 needs an Intel 80286 CPU or higher in order to run. Although OS/2 will work on 80286-based PCs (e.g., the AT) with enough memory, it runs sluggishly on these slower, older machines.

The Mac OS can run on machines with as little as 1 megabyte of RAM.

In all my testing, I haven't been satisfied with OS/2 on anything slower than a 16-MHz 80386-based PC. Such machinery doesn't come cheaply, especially when you throw in the 3 megabytes of RAM required, a 40-megabyte internal hard disk drive, a VGA, and a good monochrome monitor. Even if you put together the system yourself from discounted components, this minimally acceptable OS/2 box will cost well over $3500. And that does not include the cost of OS/2 itself, which is not distributed as a free upgrade to DOS. OS/2 can cost more than $500, depending on versions and documentation.

Let's get real now: Some Mac applications require more than 1 megabyte of RAM, particularly those that use color. If you use MultiFinder, you need a minimum of 2 megabytes of RAM, and to have a decent working set of applications loaded, you'll easily need 4 megabytes or more. The same applies for OS/2: To handle a reasonable set of programs will require 5 megabytes of RAM. Fortunately for both camps, the price of RAM is coming down, but you still have to factor in this cost if you expect to get real work done with the computers.

How They Handle

What about performance and ease of use? The Mac OS is faster at the basics of file management than OS/2, because its interface is more intuitive and easier to learn. It's also easier to use, since its windowing interface is smoother and more refined. Apple's head start shows when you sit a Mac next to an OS/2 box and play with both. Start a program, do computer housekeeping (e.g., file copying or deleting, or directory changes),

cut and paste using the Clipboards, shift from program to program, and you'll see what I mean. While OS/2 is a huge improvement over DOS, it still feels like its interface and graphics were bolted on, rather than designed from the ground up.

To be honest, OS/2 has some facilities that even Apple's System 7.0 won't have. The most important of these is full, preemptive multitasking, which lets many programs run simultaneously (if you have enough memory), so you can switch between them transparently. This is in contrast to MultiFinder, which uses cooperative multitasking to support background processing. In other words, if the foreground task is idle (waiting on a keystroke, perhaps), a background application (say, a print spooler or a terminal application doing a long download) has use of the processor.

Since most people simply want to use multitasking to perform downloads or print in the background, the benefits of OS/2's multitasking are dubious. If your work really needs serious time-sliced, preemptive multitasking, you should consider Unix. Unix is 20 years old, which means that its multitasking kernel has been beat on, debugged, and refined for a long time, and many of the graphical user interfaces that are being slapped on top of it today are no older or worse than OS/2's PM.

We use computers both to automate tasks we could do by hand and to empower us in ways that we simply can't pull off well without a technology assist. The Mac OS enables you, in many ways, to worry about the work itself and not the gritty details of how to get it done. OS/2, in its present form, does not. Maybe that's the real reason that the Mac is finally gaining acceptance in the business community, while OS/2 is still on the sidelines two years after its release. ■

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Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

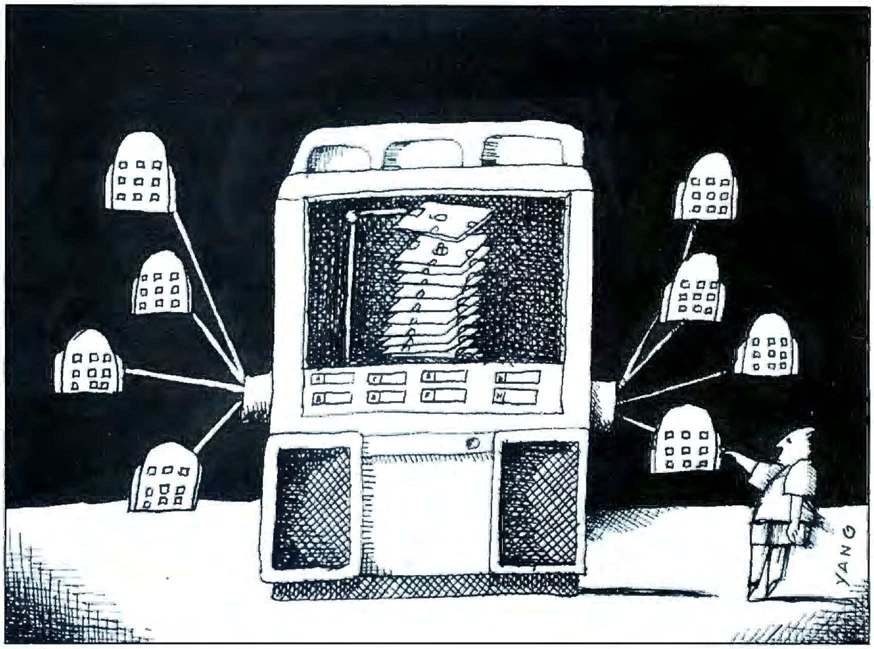
ITEMS DISCUSSED

Apple Macintosh System 6.0.3
(System 6.0.3 is freely distributed by Apple dealers. For a complete system kit, including manuals, dealers charge $45.)
Apple Computer, Inc.
20525 Mariani Ave.
Cupertino, CA 95014
(408) 996-1010
Inquiry 987.

IBM OS/2 Extended Edition with Presentation Manager version 1.1
(The list price varies according to configuration; the developer version is the most expensive. The price is $395 and up.)
IBM
Old Orchard Rd.
Armonk, NY 10504
(914) 851-0111
Inquiry 988.

WHEN ONE DRIVE IS ENOUGH

Widespread acceptance of diskless PCs could change the way LANs work



One of the key functions of a LAN is centralization. A file server is a central repository for shared applications and data, as well as a central site for regular data backup. As more and more files have migrated to LAN servers, it was inevitable that someone would ask, Do personal computers attached to LANs need hard disk drives? Or, for that matter, do they need disk drives at all?

Well, sometimes no, sometimes yes. Diskless PCs could serve the needs of many LAN users—but first they have to come down in price.

One Concept, Several Packages

A diskless PC eliminates the need for disks by booting from a network server and using that server's files. All diskless PCs operate in basically the same way, but they come in three types of packages.

The first type resembles a small-footprint PC. Samsung's (Santa Clara, CA) PCterminal/286, which Novell sold for years, is a classic example. The PCterminal/286 is a 12-MHz 80286 with four AT-style expansion slots. It includes drive bays and mounting bezels for disk drives, if you want to install one or more. The unit we examined had an Ethernet controller built onto the motherboard.

A second approach is to put all the PC circuitry into the base of the monitor, as TeleVideo Systems (San Jose, CA) does in its TS2 TeleStation. A 2-inch-high base contains a PC on a board. The monitor rises from the base on a neck.

The final approach is to hide the PC circuitry in the keyboard, as Earth Computer Technologies (Fountain Valley, CA) does. Its EarthStation IIe fits a complete 12-MHz 80286 system into its keyboard. It also requires an additional box that supplies the connectors for the monitor and LAN cables.

The diskless PCs in these packages run the gamut from those based on the old 8088 to the new 25-MHz 80386 from U-Tron (San Jose, CA). They can work with several different types of networks, including both ARCnet and Ethernet.

A Diskless Boot

To illustrate the way these systems work, we'll look at how a diskless PC boots on an ARCnet LAN running CBIS's (Norcross, GA) Network-OS, a good MS-Net-based LAN operating system for small-to-medium-size networks. CBIS estimates that as many as 20 percent of its Network-OS nodes are diskless or at least boot from the network. To boot properly, the diskless PC's network adapter must contain a Network-OS boot ROM. That boot ROM communicates with a Network-OS server via a slimmed-down version of the standard NetBIOS session protocol. You also must configure a boot server. The boot server must have one or more boot-image files. A boot-image file contains an exact image of a boot floppy disk.

You must create that boot-image file on the server. Fortunately, that task is easy: You use a Network-OS program that copies each sector from a valid boot floppy disk. That program copies everything it needs from the boot floppy disk, including the boot sector, the file access table, the hidden files MSDOS.SYS and IO.SYS, and COMMAND.COM. It also typically includes the files that a diskless PC needs to bring up a full version of Network-OS, as well as CONFIG.SYS and AUTOEXEC.BAT.

You can create several different boot-image files for different diskless PCs on the LAN. The server decides which

continued

boot-image file to use for each diskless PC by consulting NWBOOT.DAT in the Network-OS directory (\NW by default). NWBOOT.DAT contains a list of node numbers and their corresponding boot-image file names. If the diskless PC's node number is in that file, the server uses the designated boot-image file; otherwise, the server uses the default image file, BOOTOS. But while many PCs can share a single boot-image file, you still need enough DOS licenses for all the systems on your LAN.

With the server and diskless machine ready, the remote boot process is fairly simple. When you turn on a diskless PC, its ROM BIOS tries to boot the machine. It does not, however, try first to boot from drive A and then from drive C, as usual. Instead, it asks the boot ROM for the boot sector, just as a standard PC's ROM BIOS would ask its disk drive controller for the boot sector.

The diskless machine's boot ROM then uses its stripped-down NetBIOS to broadcast a message that contains its network address and indicates its desire to boot. When the boot server receives that request, it establishes a connection with the diskless machine and sends the diskless PC the required sectors from the appropriate boot-image file.

When the diskless PC receives those sectors, it boots as if from a floppy disk. The AUTOEXEC.BAT, for example, typically would bring up Network-OS and mount some network hard disk drives, so that the diskless PC would have a complete working environment.

In fact, once MS-DOS is running, you could do a DIR on drive A and see the same files as on the original boot floppy disk. If the file protection attributes of the boot-image file let you change that file, you could even modify your AUTOEXEC.BAT and CONFIG.SYS files.

Then There's NetWare

The boot process for a diskless PC on a Novell NetWare LAN is only slightly different. During the boot procedure, which Novell calls "remote reset," the NetWare boot ROM uses a stripped-down version of Novell's IPX rather than NetBIOS. NetWare handles the problem of multiple boot-image files by using an index file, \LOGIN\BOOTCONF.SYS, that is much like Network-OS's NWBOOT.DAT. Each BOOTCONF.SYS entry contains a PC's network number, node number, and boot-image filename. If a diskless PC tries to boot without having an entry in BOOTCONF.SYS, the server uses the default boot image, \LOGIN\NET$DOS.SYS.

Unlike Network-OS, NetWare does not let diskless PCs see the virtual boot disk after they have booted. Instead, it connects each diskless PC to the directory \LOGIN on the server's hard disk drive. This approach can be annoying, because the diskless PC user can't edit the AUTOEXEC.BAT or CONFIG.SYS files; only the system administrator can make such changes.

The High Cost of Diskless PCs

Both of these approaches assume, of course, that you need a diskless PC. One argument for such systems is their packaging: Diskless PCs are typically small and quiet. Because they have no disks, they run cool and don't need the often noisy PC fan. The downside to the small size is that most diskless PCs offer no expansion slots.

continued

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Best of Seven

You would think that by leaving out disk drives and fans, manufacturers would be able to sell diskless PCs very cheaply. Unfortunately, that's not true. For example, the Wyse Technology (San Jose, CA) WD-212 12-MHz 80286 diskless PC costs $1799 (see "The LAN Terminal Alternative," November BYTE). That price includes a built-in monochrome VGA monitor, but you have to buy a LAN adapter separately. Even the EarthStation I costs $995. For that, you get a keyboard, an 8-MHz NEC V40 processor, and an ARCnet adapter, but no monitor. You can find many complete AT clones in this price range.

Diskless PC vendors clearly could reduce these prices. The main reason for the high prices is that this is still a niche market with a handful of competing vendors. Expect prices to fall if this market grows or if IBM decides to legitimize it by announcing a diskless PC.

Security Flaws

One feature that many diskless PC vendors tout, perhaps as a partial justification for the high prices of their systems, is security. The idea is simple: Without floppy disks, you can't steal data.

Unfortunately, the lack of floppy disks stops only the amateur thief. All the diskless PCs we've seen have several security flaws. Chief among them is a serial port. With a serial port, a cable, and a modem, data is only as secure as the nearest phone jack. There's also the ubiquitous printer port. With a laptop and LapLink, anyone can pull all the data off your server in a few minutes.

You can prevent this kind of data theft by not letting diskless PCs use any file transfer software on the server. But while security on diskless PCs is better than on normal PCs, it's still incomplete.

A more important feature of diskless PCs is the control that they return to the network system administrator. That administrator can handle data backups, software updates, and software purchasing, all with no hassle for the user.

Sound familiar? It should; the server effectively becomes a minicomputer. This setup is very attractive to MIS departments, which have traditionally controlled computing resources. It makes installing PCs little harder than installing smart terminals. Users get the simplicity of a LAN terminal, and the MIS department regains administrative control.

Indeed, diskless PCs can be easy to install. We brought up one system by just plugging in the keyboard, network drop, and power cord, and turning it on. It immediately booted from the network.

That leaves the control aspect. PCs brought with them a kind of democratization of computing—one user, (at least) one computer—along with democracy's potential for chaos. Diskless PCs have the potential for a return to centralization; companies should decide whether they want such an environment.

Of course, the price of diskless PCs must come down. Will the market for them grow rapidly? Guessing the future is always risky, but this market may well become a major one. Diskless Unix workstations are common, and where Unix goes, PCs tend to follow. ■

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	80386 Instruction Mix	Floating Point Calculation	Conventional Memory
ZEOS 386/16 Desktop	3.58	13.62	0.58
ZEOS 386/20 Desktop	2.87	10.82	0.38
IBM PS/2 Model 70-E61	4.08	16.04	0.75
Compaq Deskpro 386/16	4.12	15.47	0.75

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ZEOS 386-16 PC MAGAZINE EDITOR'S CHOICE 2-26-89

ZEOS 386-20 PC MAGAZINE EDITOR'S CHOICE 5-30-89

ZEOS 386-16 PC MAGAZINE EDITOR'S CHOICE 5-30-89

"Out of 104 machines from 58 companies . . . For overall excellence we selected ZEOS International's 386-16 and 386-20." *PC Magazine, May 30, 1989*

The Editors of *PC Magazine* came to this conclusion after investing "25,000 hours of work by 60 people testing and reviewing 104 '386 PCs." The review was thorough and their conclusion specific. Simply, that out of all the manufacturers in the world, ZEOS offers you the very best '386 Value.

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Then add our 30 Day Absolute Satisfaction *Money Back* Guarantee, One Full Year Limited Warranty and Express Parts Replacement Policy. You've got the best.

And when you order your ZEOS '386 you can have your pick from the industry's broadest selection of options. As *PC Magazine* said, ZEOS offers "more options than even the most configuration hungry hound could possibly need."

Quality, Performance, Reliability and Support. *Overall Excellence.* That's why ZEOS is PC Magazine's *#1* choice. And that's why ZEOS is *your best choice as well.* So pick out that dream machine today and order it now with confidence. Your choice of ZEOS excellence is Guaranteed. Order now by calling 800-423-5891.

"Price is always a consideration. So are benchmark test results. But both factors can be deceiving, which is why we consider them in the context of other aspects that will make the difference months and years down the road. Things like quality of construction, reliability, expandability, and ease of service."

PC Magazine, On "What Makes an Editor's Choice"

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	80386 Instruction Mix	Floating Point Calculation	Conventional Memory
ZEOS 386/25 Desktop	2.29	8.37	0.33
ZEOS 386/33 Desktop	1.67	6.43	0.27
IBM PS/2 Model A	2.27	8.33	0.60
Compaq Deskpro 386/25	2.36	8.59	0.37

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Performance Comparisons using PC Labs Benchmark Series Release 4:

	80286 Instruction Mix	Floating Point Calculation	Conventional Memory
ZEOS 286/12 Desktop	4.78	18.84	0.72
IBM PC AT (8MHz)	8.96	35.60	1.32
IBM PS/2 Model 50	7.20	28.34	1.05

- *Fast 32MB Seagate 138R Hard Drive with auto-park, 1.2MB Floppy Drive.*
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ZEOS 386-20
PC MAGAZINE EDITOR'S CHOICE 5-30-89

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- *Ultra high speed Hard/Floppy SCSI controller.*
- *Genuine Hercules® Brand graphics card. High-Res Amber Display with Tilt/Swivel Base.*

Performance Comparisons using PC Labs Benchmark Series Release 4:

	80386 Instruction Mix	Floating Point Calculation	Conventional Memory
ZEOS 386/20 Desktop	2.87	10.40	0.39
IBM PS/2 Model 70-121	3.24	12.72	0.61
Compaq Deskpro 386/20e	2.91	10.54	0.40

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Making a Case for CASE

The journey is its own reward

The BYTE Staff

Ask a dozen people what computer-aided software engineering is, and you'll get a dozen different answers. CASE tools can assist in the planning, analysis, design, documentation, prototyping, and construction of business information systems, in accordance with one or more popular software engineering methodologies. Advocates say that, used properly, CASE tools help produce correct and maintainable software; detractors say that CASE tools produce nothing and end up as shelfware.

Despite the confusion surrounding CASE, there's no shortage of CASE tools. The BYTE Lab looked at a representative sample of those tools that run on the PC platform: DesignAid, DesignMachine and DesignVision, Excelerator, IEW/WS, MicroStep, POSE, and Teamwork OS/2. Reviewing CASE tools isn't like reviewing, say, C compilers. Ultimately, the compilers all do the same job—transforming ANSI C source code into executable programs. But CASE tools tend to favor particular software engineering methodologies and to attack different parts of the software life cycle. Each, to a large extent, defines the context within which it must be judged. Table 1 shows the methodologies and life cycles of each product.

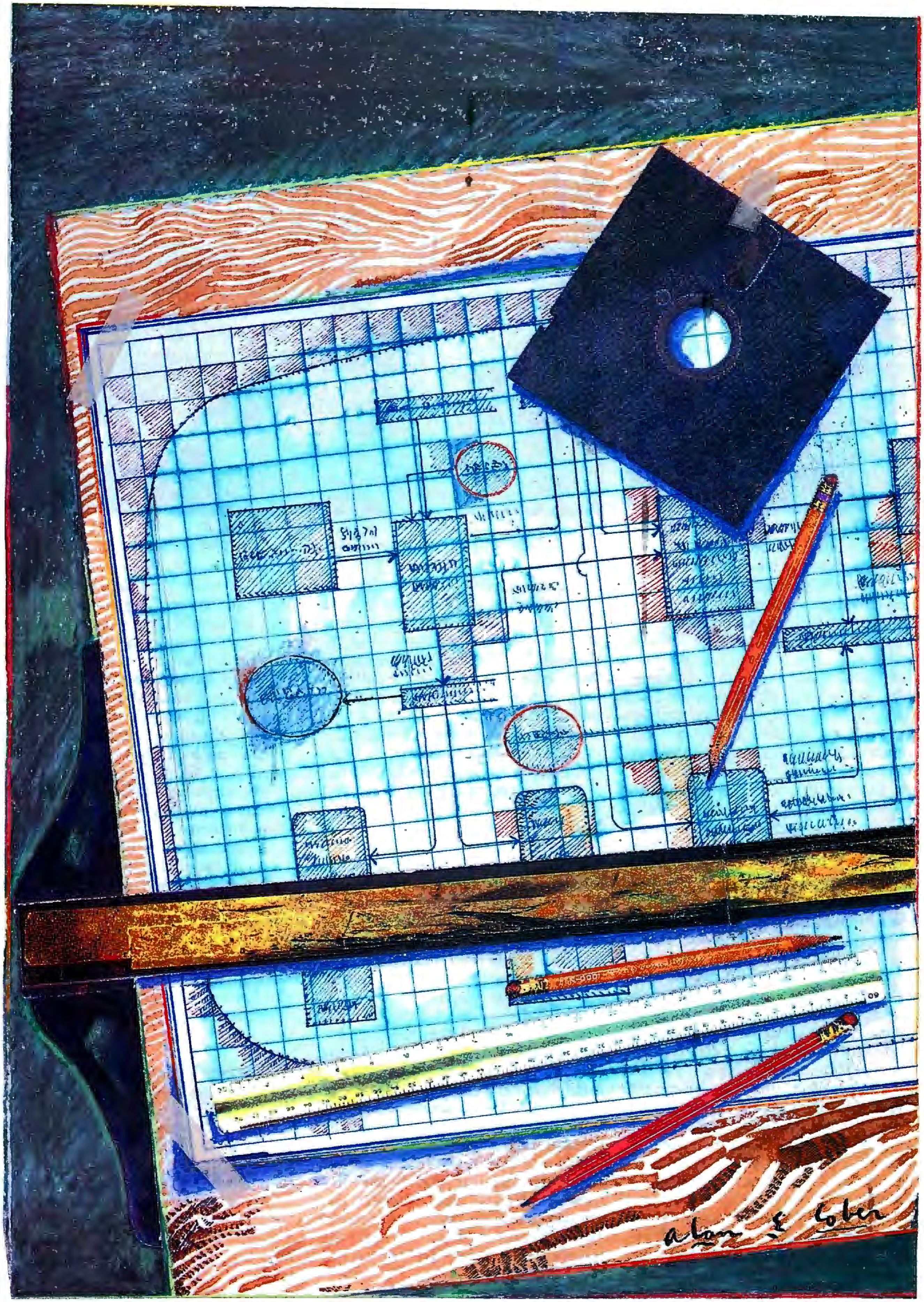
To test the products, we defined a sample software project, paired each CASE product with a BYTE editor, and asked each editor to work through the project using the assigned product's methods and tools. Textbooks and tutorials often teach CASE concepts in terms of accounting and inventory systems. But we chose a business information system that's nearer and dearer to our hearts: the solicitation, editing, and tracking of articles here at BYTE. Such a system would enable staff members to share a database containing information about authors, contracts, and manuscripts.

Our requirements were deliberately vague. Why? CASE proponents argue that correct definition of system requirements and correct database design are the key components of quality software. Many software engineering methodologies address the requirements analysis and design phases. In particular, we wanted to examine how the tools can help with these critical parts of the software life cycle. Of course, we were also curious to see how far we'd get toward a working system using each tool.

We'll save you the suspense: Our proposed system remains vaporware. Is that a failure of the CASE tools? We don't think so. The tools, in general, produced specifications—for a database to support our proposed system, and for the processes that perform transactions on that database. That's valuable, especially for large and mission-critical systems (unlike ours) that can't be designed on the back of an envelope.

The accounts that follow detail each editor's experience with CASE tools. There's a common refrain in these seven accounts: The journey is its own reward. CASE suffers from unrealistic expectations. Software development remains a tricky business, and the CASE vendors we spoke to don't pretend otherwise. CASE tools can help define (or, possibly, build) systems, but there's no magic involved. The CASE process, like programming, requires dedication and skill.

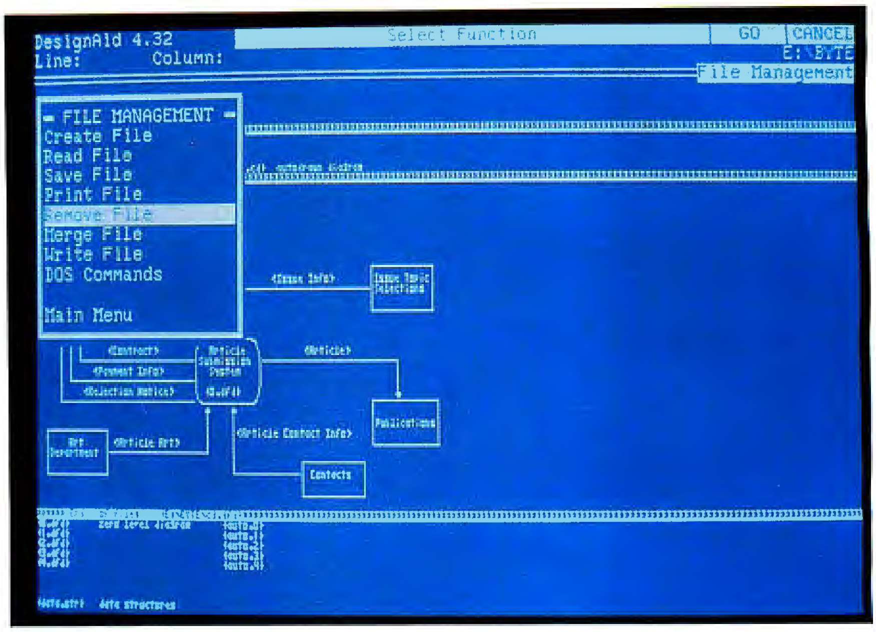
continued



ILUSTRATION: ALAN E. COBER © 1989

DesignAid

The DesignAid interface resembles an outline processor. This photo illustrates a context-level diagram embedded within a menu file. Filenames enclosed in brackets can be called using the displayed File Management menu.



We've all heard the horror stories about good programmers who generate only 10 lines of working code a day. Nastec's DesignAid can enhance that ratio by helping with the organizational up-front work that is vital to any large software project.

At first, I had expected a do-everything product that effortlessly modeled your software needs and then cranked out reams of faultless code—in short, miracle software. For the price ($6900), it didn't seem like too much to expect. But DesignAid brought me around to a more realistic understanding of CASE tools and, ultimately, a better appreciation of the CASE philosophy.

DesignAid works a lot like an outline processor. You build a project in a menu file. It contains references, enclosed in brackets, that refer to disk files. Each nested file retains its autonomy, so that only the file at the top of the "stack" can be saved. This method still lets you track all components of a project from within one integrated structure.

Once you've created a menu file, you might enter a reference for a top-level Data Flow Diagram. Bracketed file references placed within the flowchart's symbols provide access to further system detail. The tools for drawing and editing symbols are adequate, and the menu interface is easy to navigate, but connecting lines and aligning symbols often took a bit of trial and error.

The diagraming facility supports the full Yourdon/DeMarco methodology. The Data Modeling option ($1500) generates Chen entity/relationship diagrams, and the optional Real-Time module ($1500) supports Ward/Mellor methodology.

DesignAid has an Autodraw function. The problem is that Autodraw requires either a dictionary containing diagrams you've already drawn and validated, or a Diagram Description File. You create a DDF by entering formatted definition statements into an ASCII file, which you submit to Autodraw. In the end, it's just as easy to draw things yourself. I used validated drawings to test the Autodraw function. It did a creditable job, correctly placing objects and data flows.

Putting DesignAid to Work

I began our model by creating a context diagram showing the Article Submission System and how it relates to external inputs and outputs (e.g., Author and Art Department). An embedded file reference in the Article Submission box referred to a *zero-level diagram* that presented an overview of the system. Included in this diagram were the data stores (Author File, Article File, and Contract File) and the principal processes (Solicit Article, Accept Article, Perform Technical Editing, and Perform Final Editing). Each of the processes also contained references to nested files. With this structure in place, it was easy to traverse the diagram hierarchy.

The next step is to decompose flowcharts into detailed process narratives (pseudocode) and data structures. For example, one of my flowcharts contained an object called Article Text. To this object I attached a data structure and defined its elements—Text, ID, and Version. DesignAid's validation tool checks diagrams for accuracy and completeness before allowing design information to enter your dictionary. DesignAid checks for proper graphical syntax and verifies that, for example, the inputs to and outputs from a child process match those of its parent. The process ensures that all objects in the diagram are defined.

You can also build your dictionaries manually. In fact, you could start your design by defining the objects in your system and then create a DDF file to automatically generate your diagrams.

The normalizer interrelates the data structures that you've defined and produces a schema that you can easily feed to a relational data manager. After specifying all the objects in our sample system, it was a simple matter to create a data structure list for each object. That was all the normalizer needed. I submitted the structure list, and the normalizer returned a set of tables in first, second, and third normal forms. I then submitted the normalized output to Autodraw, which dutifully charted each of my relational views.

The Network Connection

All this organizational work is a natural for networking, and Nastec does not disappoint. While some packages allow you to download portions of a design dictionary, DesignAid's dictionaries can be truly shared and are thus accessible to everyone on the network. The administrator sets access levels for each team member. With full access, you can view objects in the dictionary as well as modify or delete them. Limited access grants usage of the dictionaries while preventing

Table 1: *Each CASE tool has its own mix of methodology and life-cycle support.*

METHODOLOGIES AND LIFE CYCLES

CASE tool	Hardware needed	Methodology	Life cycle	Price
DesignAid 4.3	Any PS/2 or AT compatible with hard disk drive, 640K bytes of RAM, EGA (or VGA with an EGA mode) or Hercules graphics card, and DOS 3.1 for LAN support (or DOS 2.1 if stand-alone). A mouse is highly recommended.	Yourdon/DeMarco, Chen (optional), Ward/Mellor (optional)	Planning, analysis, design	$6900 Data Modeling option: $1500 Real-Time module: $1500
DesignMachine 2.0	AT, DOS 3.0, 640K bytes of RAM	DSSD	Planning, analysis, design	$1995
DesignVision 1.7	AT, DOS 3.0, Windows, 640K bytes of RAM	Yourdon, Gane/Sarson, Warnier/Orr, user-defined Chen	Planning, analysis, design	$995-$2995
Brackets	PC, XT, AT, DOS 3.0, 512K bytes of RAM		Structured COBOL programming	$150
Excelerator 1.84	PC with hard disk drive, 640K bytes of RAM, mouse, graphics board	Yourdon, Gane/Sarson, Chen, Merise	Planning, analysis, design, construction	$8400
IEW/WS	80286-based system or higher, DOS 3.1 or higher, 5 megabytes of RAM, 20 megabytes of hard disk space, Microsoft Mouse (serial) or compatible	Information engineering	Planning, analysis, design, construction	Planning: 8625 Analysis: $8625 Design: $8625 Construction: $8625 (volume discounts available)
MicroStep 1.3	AT, 80386, PS/2, or compatible, 640K bytes of RAM, 20-megabyte hard disk drive, EGA or Hercules video card, Microsoft or compatible mouse, DOS 3.1 through 3.3	Yourdon	Design, construction	$5750, including three days of training (volume prices and site licensing agreements are available)
Teamwork OS/2 3.0	IBM PS/2 or Compaq, OS/2 Standard Edition or Extended Edition 1.1, 5 megabytes of available RAM (6 if used with OS/2 Extended Edition), 7.2 megabytes minimum available on disk	DeMarco, Ward/Mellor, Schlair, Constantine	Planning, analysis, design	$4995 Teamwork/RT module: $1500 Optional maintenance: $750
POSE 4.0	PC or compatible, DOS 3.0 or higher, 640K bytes of RAM, hard disk drive, two- or three-button mouse, CGA or higher, HPGL-compatible plotter or graphics printer	Yourdon, Gane/Sarson, Constantine, Finkelstein, information engineering	Planning, analysis, design, construction	Single module: $595 Toolkit: $1195

any modification of them. You can also lock specific dictionary records or prevent access to DesignAid altogether.

DesignAid can be useful for managing large software projects. It's not perfect, of course. The normalized output works well as a database development aid, but I wish the program generated standard schemata that could be plugged directly into a database front end. Diagraming could be more convenient, and the prototyping facility needs some enhancement.

However, the company appears ready to plug some of the holes. Nastec already supports links to the Telon code generator (you export DesignAid screens and reports, and Telon spits out the code), and the company's merger with Transform Logic Corp. portends more integration (including schema generation) in the future.

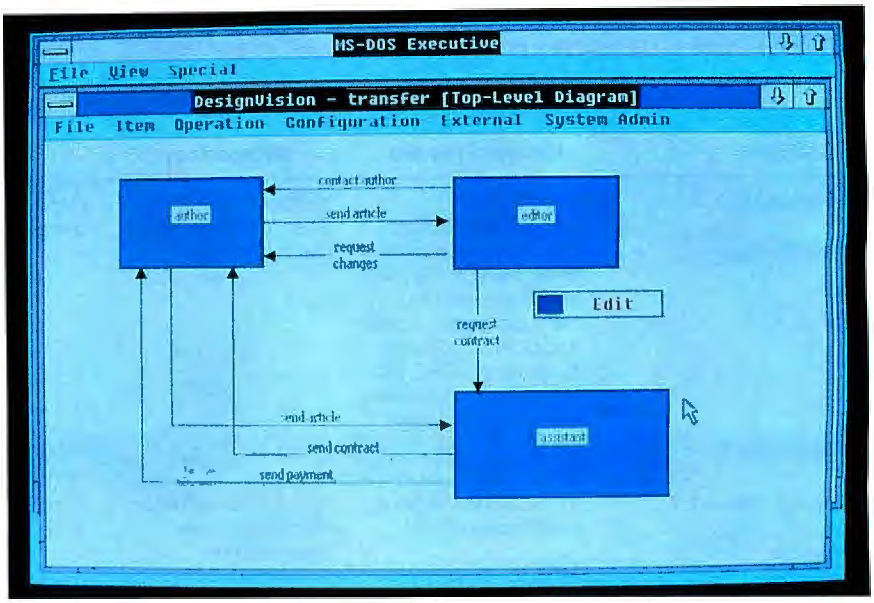
I guess I'm a CASE convert. I just can't imagine that dedicated use of such a package wouldn't dramatically increase the productivity of a design team.

—Stanford Diehl

continued

DesignMachine and DesignVision

DesignVision supports user-definable diagrams and a SQL query facility under the standard Microsoft Windows interface.



Optima (formerly known as Ken Orr and Associates) offers a family of tools that support Orr's DSSD (for Data Structured Systems Development) methodology. DesignVision is a diagraming tool. DesignMachine guides an analyst through the sequence of activities defined by DSSD, culminating in the definition of a normalized relational database. Brackets is a specialized outline processor used to create and modify Warnier/Orr diagrams and transform such diagrams into COBOL programs.

A DSSD analyst begins by capturing the views of each user of an information system. The analyst then merges the resulting entity diagrams to create a combined diagram that accounts for all users and all transactions. These diagrams enable users to see—and to correct—the representation of a system. The analyst then focuses on the transactions, specifying the order in which they occur, their component data elements, the outputs that incorporate that data, the processes that produce the outputs, and the logical structure of the data. The idea is to help people discover what data they require and how often and in what ways they interact with that data. A database derived from such analysis stands the best chance of serving the needs of its users.

DesignMachine and the DSSD Process

DSSD is a complex algorithm. DesignMachine won't teach you DSSD, but it will ensure that you perform the steps in the proper order and that you complete each one before proceeding to the next. It also automates the production of the multitude of *deliverables*—entity diagrams, process flowcharts, and database and output specifications—that DSSD mandates.

DesignMachine requires a full 640K bytes of RAM. I had to unload my network shell, which underscores the fact that, although a DSSD project is inherently a shared effort, there's no multiuser support from Optima yet.

I modeled our sample problem with the help of a DSSD trainer. In a day and a half, we worked through a portion of the problem and produced a normalized relational schema.

One of the best things about DesignMachine is that it draws entity diagrams automatically, although they are not fancy. The program's interface is a primitive character-based one that reflects the mainframe style of the applications that CASE tools have traditionally been used to develop. But it does draw the diagrams. Consequently, you don't spend time aligning bubbles and neatening connectors. Instead, you concentrate on defining your system.

The problem, however, is that there's no quick way to pump information into the system. You create a transaction on one screen, specify its source on another, and specify its destination on yet another. Furthermore, you've got to document everything. You can't, for example, add an entity called Art Department without also supplying your name and a one-line description of the entity.

Even more frustrating, when I added the transaction Figures To Art, specifying Editor as source entity and Art Department as destination, DesignMachine refused to let me complete the combined entity diagram. Why? I hadn't specified the reciprocal transaction. DesignMachine knew this, and it even highlighted a proposed Art Department-to-Editor link; nevertheless, it forced me to go back and add it manually. I'll grant that rigor is desirable, but I wished that the system could have been more helpful.

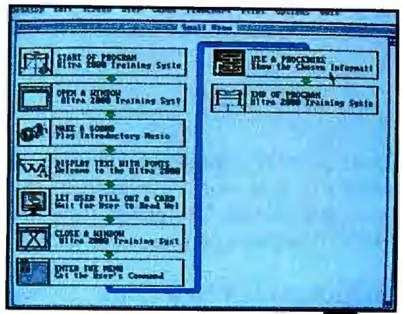
The system should also be a lot more informative than it is. Frequently, DesignMachine prevented me from completing one phase and continuing to the next, without explaining what I needed to correct. This can't simply be attributed to DSSD inexperience. I worked closely with a DSSD expert who was stumped several times.

Here is a typical example: At one point, I couldn't complete the Main Line Functional Flow Diagram, so I couldn't proceed. This diagram is a high-level view of a system's functional parts—a Warnier/Orr diagram that you might export to Brackets for further decomposition. The diagram depends, I found, on an ordering of transactions established in a previous step. I had added a transaction without saying anything about its sequence. But the only clue that something was amiss was DesignMachine's refusal to present the menu choice that led to the next subphase. There was no error message; I simply poked around until I found the unsequenced transaction, fixed that, and then was able to continue.

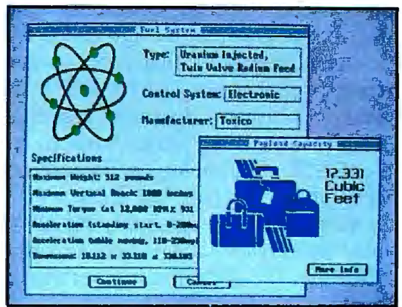
Despite these frustrations, I still like DSSD. Its premise—that users of an information system must drive the design of that system—rings true. The methodological approach to the solicitation and elaboration of users' requirements also appeals to me. The real world is messy.

continued

The Five Secrets of Power Programming.

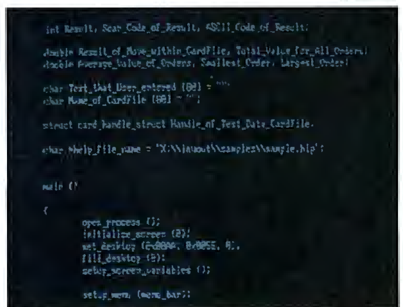


1. Design and build your programs by using a simple flowchart.

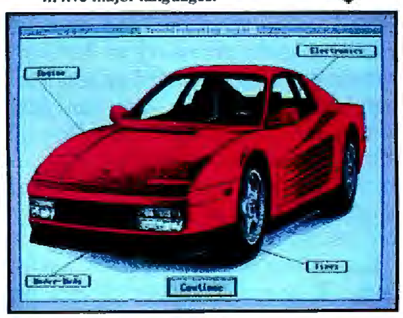


2. Create Hypercard®-like cards, linked to information in any file.

3. Use the Paint tool to create powerful graphics and buttons.



4. Layout creates real source code in five major languages.



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Consequently, software systems that model the real world are hard to think about. I wish that DesignMachine made DSSD friendlier and more accessible.

DesignVision: A New Look

Apparently, I'm not the only one to make this observation. DesignVision, a Windows-based program, represents a new direction for Optima. DesignVision is an intelligent diagramer that contains rudimentary support not just for DSSD diagrams, but also for diagrams associated with the Yourdon, Gane/Sarson, and other CASE methodologies. By rudimentary support, I mean that DesignVision can manipulate the symbols, but not the syntax used in such diagrams. According to Optima, the forthcoming version 2.0 will enable users to specify rules that govern diagrams (by the way, it will also support multiple users on a network).

The current version of DesignVision, although it has no knowledge of DSSD and so can't enforce the methodology's conventions, answers the need for a brainstorming tool that can gather a lot of information quickly and then feed it to DesignMachine. Optima hopes to make such exportation unnecessary; the company plans to move the methodology support that is DesignMachine's raison d'être into DesignVision.

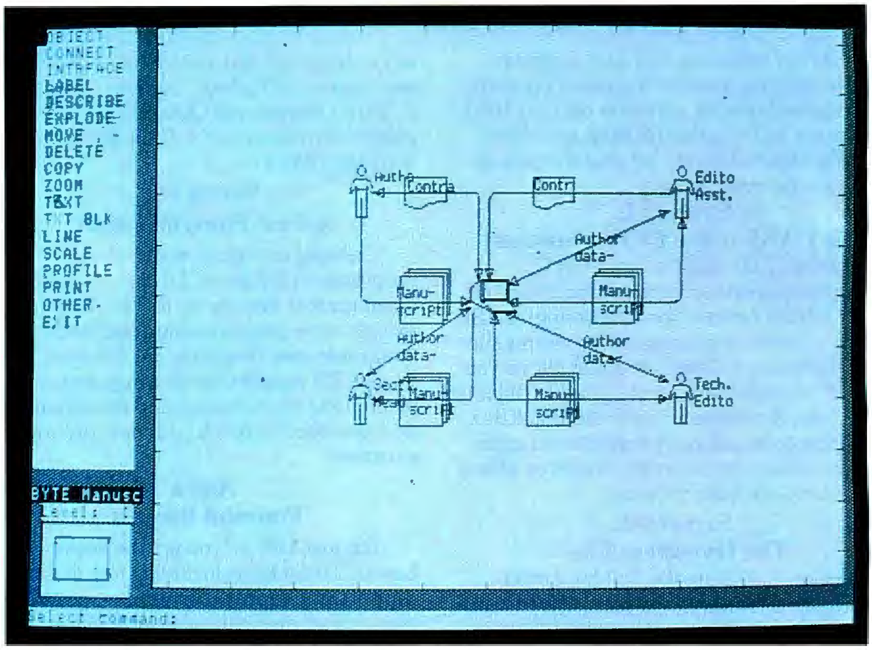
DSSD aside, DesignVision offers interesting capabilities. In a sense, it is a shell that can potentially support a variety of CASE tools or, more generally, graphical databases. A SQL engine is at the heart of DesignVision, and a SQL query mechanism affords flexible and convenient access to the data dictionary.

The symbols that can appear in the types of diagrams known to DesignVision appear as objects in that dictionary. You can extend the list of supported diagrams by creating new sets of symbols. These new symbols—which can be stylistic variations of existing symbols, or even bit maps—automatically become menu choices in the drawing system and slots in the database.

If you are thinking about getting started with DSSD, wait for the next release of DesignVision. What's needed is the right mixture of ease of use and rigor. Optima is moving in that direction, but it's not there yet.—*Jon Udell*

Excelerator

Excelerator's presentation graphs help users visualize an existing or proposed information system.



Index Technology's Excelerator provides a multiuser approach to the analysis and design of information systems. It offers the tools necessary to develop an overview of a database and an application that interacts with it. You can design functional "top-down" data-flow diagrams using a central project dictionary. Excelerator also provides detailed analysis reports and can help you prototype screens and reports.

Excelerator works in a LAN environment. A system manager creates projects, assigns users to project tasks, and assigns access levels. Users can read the central dictionary (if granted the privilege to do so), but they must mirror their portions of it to their own workstations in order to update the contents.

Excelerator's presentation graphs help in the requirements definition phase. With these, analysts can help users to visualize an existing or proposed information system. Unfortunately, these graphs don't link to the analysis modules.

Given a set of requirements, you can model the data in one of two ways: by first building a dictionary of data records and elements, or by drawing a data-flow diagram and defining elements as you go. Excelerator supports Yourdon and Gane/Sarson data-flow diagrams and Chen and Merise entity-relationship diagrams. Constantine structure charts and Jackson structure diagrams are both available to help analyze process logic.

Excelerator provides analysis reports and checks for errors, such as unbalanced levels. Although Excelerator doesn't enforce a methodology that leads automatically to the production of a normalized database schema, one set of reports tells you what you'd need to do to put the tables you've defined into third normal form. The generic version of Excelerator that I worked with can transform database record descriptions into BASIC, C, COBOL, and PL/I. Other versions export to dBASE II or Telon or MicroFocus COBOL. All versions retail for $8400.

I used Excelerator 1.84 to tackle our sample problem. I started by establishing a dictionary. I defined the records and

data fields and later related them to the diagrams I drew. Unlike some systems that lock you into completing every step, Excelerator let me exit whatever I was doing, go to another task, and return to define an element whenever I wanted. I also tried starting a project before defining a dictionary, and Excelerator let me define elements whenever I was ready.

For the most part, Excelerator lets you jump into a project almost anywhere in the system. If you see that you need a new process, you can add and define one on the fly. The same holds true for data elements. That's part of the real power of Excelerator: You can easily update and modify your project.

Not everything was easy, though. For example, diagraming in Excelerator requires a lot of patience. Although you can select either straight or piped connecting lines, Excelerator does a poor job of managing where they go. I spent most of my diagraming time redrawing crossed lines. Excelerator does offer a choice of either "system" or "user" ports, a function that lets you or the system choose the point on the diagramed entity to which the line connects. But I found that I had to redraw virtually every connecting line. It would be better if Excelerator could route the connecting lines automatically. It would be better still if Excelerator could draw the diagrams automatically.

Excelerator handles errors well. For example, a level balance check yielded several data-flow errors and related all of them back to the parent process. From there, it was easy to correct the problem by simply adding the missing data flow.

Screen and report prototypes draw information from the data dictionary. If you defined all the data elements completely, Excelerator will handle data fields and filter input data automatically. Excelerator generates the BASIC, C, COBOL, or PL/I code that is necessary to create the screens you design. The prototype screens let you build a simple "screen data file" that you can use to demonstrate the screen. However, you can't connect the screens; each prototype screen stands alone.

Excelerator offers a powerful facility for querying the data dictionary, based on *entity lists*. Every element in the dictionary—data record, screen, diagram connector, and so on—is considered an entity. You can group entities into lists on which you can perform set operations such as union, intersection, difference, and subtraction. Using entity lists, you can answer questions like, "What modules will be affected if I change the name of this data element?"

Generally, Excelerator is easy to use, although its user interface could be improved. Specifically, when you have to provide an element or record that's already defined in the dictionary, Excelerator usually gives you a list to choose from—usually, but not always. For example, when you add a data element, you normally say to what record it's attached. But Excelerator does not provide a list of the record names in its dictionary, and if you misspell the record that you want the data associated with, the system creates a brand new record.

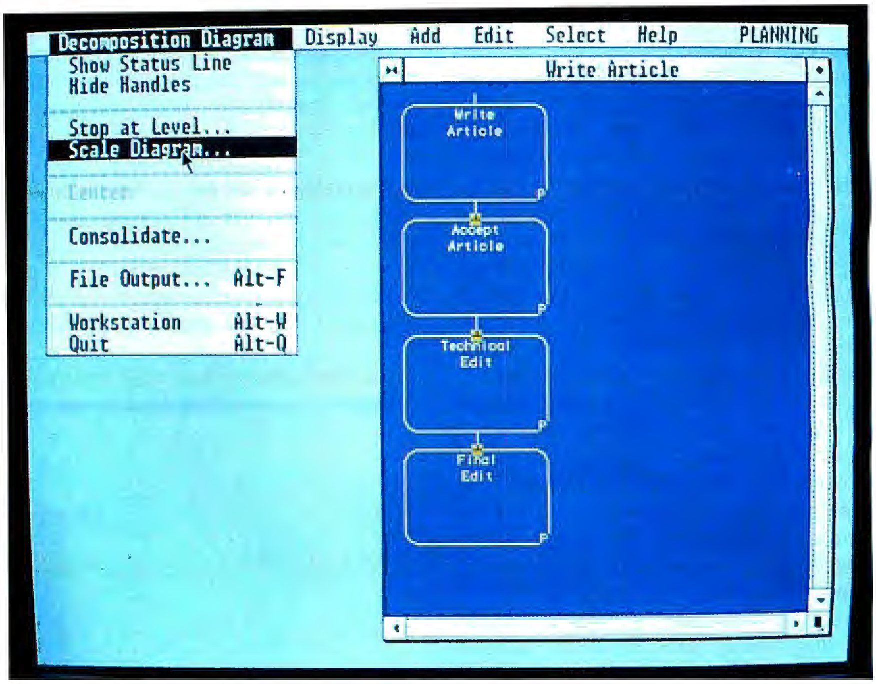
The company says an upcoming version 1.9 of Excelerator will correct that. Otherwise, I found Excelerator to be a solid tool for analysis and design. Its centerpiece—the data dictionary—cooperates nicely with the analysis modules and features a nice query mechanism.

—Dennis Allen

continued

IEW/WS

KnowledgeWare IEW/WS: The Action Diagram details the processes of your system in a hierarchical structure. You can call up help screens at any time.



The KnowledgeWare Information Engineering Workbench/Workstation (IEW/WS) is a set of integrated CASE tools that run on microcomputers but are designed to develop mainframe COBOL applications for the IBM MVS environment.

These tools are designed for experienced analysts and developers who are familiar with CASE tools and who want to develop software products for corporate environments. I stress the words *experienced* and *corporate*: The IEW/WS software will not teach you how to use CASE tools.

The documentation is complete, and the program modules are replete with help windows, but that's not enough for an inexperienced user. KnowledgeWare offers optional training seminars.

The set of modules includes the Planning Workstation, the Analysis Workstation, the Design Workstation, and the Construction Workstation. These can be used separately or together. All the modules, except for the Construction Workstation, operate under a run-time version of GEM, Digital Research's graphical user interface. The Construction Workstation uses a run-time version of Microsoft Windows.

The hardware overhead is considerable. The IEW/WS modules require an 80286-based system or higher, a minimum of 5 megabytes of RAM (7 megabytes is recommended), 20 megabytes of hard disk space, an EGA or VGA display, and a Microsoft-compatible mouse.

GEM gives modules a common, intuitive user interface. You use a mouse to access menu bars and pull-down menus, and to manipulate multiple windows.

Planning, Analysis, Design, and Construction

The Planning Workstation module is used to organize, model, and analyze knowledge about the goals, problems, functions, and resources of an organization. You can use it to model the existing flow of information, resources, or products within a system or to define the goals of a new system.

Information is entered into the Planning Workstation via a set of diagrams. Decomposition diagrams display a hierarchical view of the objects in a system. Matrix diagrams provide a list of the objects in the system and the interrelationship between the processes and the data they require. Entity diagrams provide a graphical display of the people, things, and ideas in the system.

One of the most powerful aspects of the IEW/WS modules is the Knowledge Coordinator. It uses a built-in set of over 1000 diagraming rules to restrict you from entering information that is logically inconsistent or incorrect. When I was building my decomposition diagrams, the Knowledge Coordinator pointed out several logic errors. For example, the Edit Article process produced an output (the edited article) without receiving any input (the rough draft).

This information is stored on the hard disk in the KnowledgeWare Encyclopedia. The Encyclopedia contains all the information and the relationships between the various objects in all the diagrams. This means that the diagrams will always be consistent.

The Analysis Workstation takes the information you entered into the Planning Workstation from the Encyclopedia and further refines it to create models incorporating the data and processes and showing their interrelationships.

By means of data-flow, entity-relationship, and action diagrams, you define what a particular area of the system does and how information is created, exchanged, and modified by the processes in your system. This module helps you determine which areas in the system need to be automated. For example, I found that the Receive Article function could not lead directly to the Accept Article function, so I returned to the Planning Workstation to modify the design.

The Action diagram is especially useful in detailing the processes of your system. It uses brackets and narrative notation (brackets can be nested) to represent the hierarchical structure of the processes and subprocesses in your system.

The Design Workstation also reaches into the Encyclopedia and, using the further refined information from the Analysis Workstation, models the processes and data in physical detail.

You use the Design Workstation to build screen layouts, physical files, database definitions, menus, and procedural logic. In terms of BYTE's fairly simple sample problem, I could have used the Design Workstation to create an Action

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Diagram and layout screens and to define the data structure from scratch.

Actually, I used the Design Workstation to create menus and screen layouts that corresponded to some of the paper forms that now accompany each manuscript. My design mirrored the existing paperwork system.

After you've gone through all the previous modules and refined your system design, you can use the Construction Workstation to generate source code. The Construction Workstation takes all the design specifications from the Encyclopedia, adds instructions for code generation depending on the type of system you have designed and the target computer system, and generates the code.

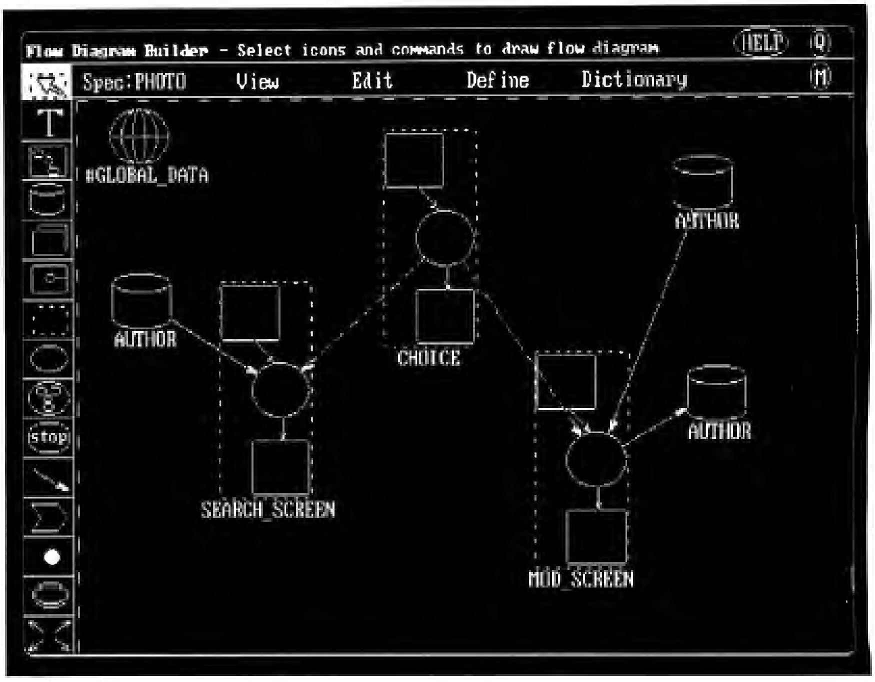
The IEW/WS tools do not restrict you to one particular methodology. Rather, they incorporate general principles from many standard software development techniques. You are free to use Martin, Yourdon, DeMarco, Gane/Sarson, or other methodologies.

The KnowledgeWare IEW/WS tools are sophisticated, powerful, and complex. They are tailored for mainframe software development. This may be the most comprehensive set of CASE tools available for creating mainframe COBOL applications.

—Stan Wszola

MicroStep

MicroStep produces executable application programs based on your data-flow diagrams. These diagrams emerge through simple point-and-click placements of icons.



Syscorp's MicroStep offers what many people expected all along from CASE tools: executable application programs generated from graphical specifications. MicroStep creates PC-environment C source code and feeds it to the Lattice compiler supplied with the system.

Syscorp markets the product for business system developers, including MIS managers, who want to speed application development and bypass programming-department backlogs. The trade-off? It's a self-contained system that doesn't support large-scale structured analysis and design, and it can't bridge to external data managers and software development environments.

Syscorp describes the underlying methodology as Yourdon "with extensions," meaning the software shares a Yourdonian penchant for up-front data-flow diagraming, modeling, and analysis, but extends this procedure to include code generation.

Syscorp's three-day training seminars are held at its Austin, Texas, headquarters. The $5000 price of the software doesn't include this training, which costs an additional $750 (customer-site training is available at negotiated rates).

In addition to formal seminars, Syscorp offers an accessible and helpful technical-support staff for telephone questions. Also, tutorial and training manuals arrive with the software. Either can be used as self-guided instruction materials.

Taking the Plunge

After two days of working through Syscorp's comprehensive training materials, I felt comfortable with the interface's icons and the sequence of steps necessary to generate code. But I needed further help from Syscorp's training staff before I could make the leap from training exercises to building pieces of our editorial department model.

You begin with flow diagrams that outline how data will pass through the application. Flow diagrams emerge through simple point-and-click placement of data-object and connector icons from MicroStep's diagram builder. Some icons, such as those representing databases, invoices, and processes, are easily recognizable. Others, such as the *subspecification marker* (a symbol that links to a submodule), may be unintelligible at first glance.

Next, you define data structures by establishing fields within the databases you created in the flow diagram. Using icons and dialog boxes, MicroStep coaches you through naming fields and notes whether they will hold text or numerical data. New fields are placed to the right or left of existing fields using the appropriate icon. MicroStep enables you to create data dictionaries that can be imported into other applications.

Then you develop the screens and reports that users of your application will see. A simple but adequate text mode lets you enter copy, such as name and address

boilerplate fields on invoices. Text positioning is a simple matter of placing an icon in the desired area. Once your text is entered, you can easily move it around the screen to experiment with various layouts. Creating formats for user screens is similarly flexible. Taking cues from MicroStep dialog boxes, you develop screen elements with the text mode or the drawing icons, which let you "rubberband" boxes and rectangles.

Finally, you describe the application's computations and processing logic using an Activity Builder screen that displays a series of menu choices that you simply point to and click on with your mouse.

When you've completed your specification, MicroStep's analyzer tells you if your specification is incomplete or contains inconsistencies. For example, in my author-lookup function, I added a lookup condition to flag the author-not-found case, but I failed to define it. The checker found the problem and told me how to fix it. Once you have developed and checked your specification, you can instruct MicroStep to generate and compile the code.

Before you attempt to run MicroStep, be sure you have a full 640K bytes of RAM. Syscorp instructs you to remove network software and most TSR utility packages. I ran MicroStep with a 20-MHz 80386 clone and was glad to have the power.

The version that I evaluated (1.3) didn't accommodate either extended or expanded memory. Syscorp plans to support extended memory in future versions but currently has no plans to address expanded memory. MicroStep also requires EGA or Hercules video support and a Microsoft or compatible mouse.

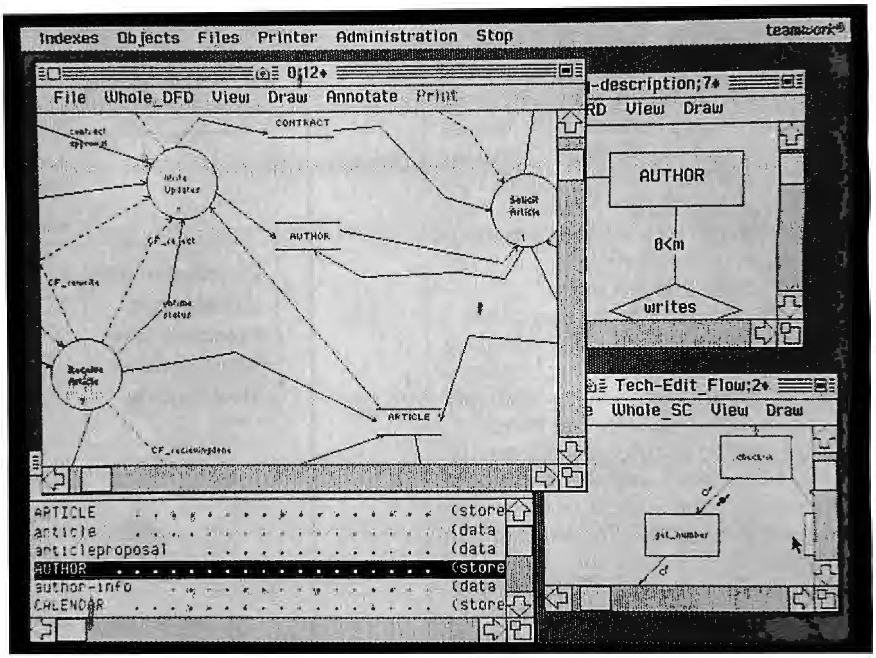
The application that I eventually produced was alarmingly big—nearly a half-megabyte, despite being a small piece of our sample project. (The company says that it's working to reduce the overhead of MicroStep-built applications.) And the functions and variable names in the generated code are cryptic. It's effectively object code rather than source code. Syscorp's approach requires you to maintain your MicroStep application at the specification level.

MicroStep is best suited to nonprogrammers who want to develop small- to medium-size database applications. The current version doesn't support the development of networked applications. The company says that future releases will generate applications for multiple users and allow multiple users to develop a single application.—*Alan Joch*

continued

Teamwork OS/2

Teamwork OS/2 smoothly integrates analysis and design tools into a windowing environment. The focus is on data-flow diagrams and DeMarco methodology.



Cadre's Teamwork OS/2 has an edge on the rest of the PC CASE pack. It takes advantage of OS/2 to provide a very comfortable, multiwindowed environment you just couldn't hope to support with DOS. One warning, though: The product likes *a lot* of memory—I kept getting memory-limit crashes on an IBM PS/2 Model 80 with 6 megabytes of RAM until I set up a large swapping area on disk and disabled all external processes.

Teamwork integrates three modules into this environment: Teamwork/SA, for structured analysis; Teamwork/IM, which supports information modeling; and Teamwork/SD, for structured design. Our review package also included Teamwork/RT, an optional module that adds real-time extensions to SA.

Analysis Tools

The structured-analysis tool enables you to create data-flow diagrams and process specifications according to the DeMarco methodology. The primary interface to this system is the data-flow diagramer. It's a graphical editor that lets you create processes, stores, and terminators, and link them with data flows. Each store and data flow eventually requires an entry in the data dictionary, but Teamwork does not force you to define each element as you draw. I was able to graphically sketch the data flows of the current editorial system in a few hours; refinements took several days.

To define a data flow or store, you bring up the Data Dictionary Entry (DDE) editor. Unfortunately, each element you define requires that you fire up a new instance of the DDE editor, which quickly gobbles memory and takes several seconds, even on a PS/2 Model 80. If you try to define a number of objects by this method, the screen quickly fills with DDE editor windows that each describe only a single element. The only efficient way to define multiple elements is to create an external dictionary with a word processor and import the file.

The data-flow diagram editor supports leveled DFDs, allowing you to create child DFDs for each process. But because Teamwork doesn't automatically balance parent and child diagrams, revisions are complex. Instead of just adding a new data flow to a parent and having it appear on a child process, you must add it to both and run a check to ensure that the diagrams balance. Cadre, which promises a multiuser version of Teamwork OS/2 in the near future, purposely designed the diagramer without the automatic inheritance to facilitate its use in a multiuser environment.

When you've broken a DFD down to its primitive processes, you use a text tool (the P-spec editor) to describe each primitive. A primitive process is a function like Assign Article Number, which cannot be decomposed readily and is easily described in structured English or pseudocode.

Analysts working with real-time systems often have special requirements not covered by formal DFDs. The Teamwork/RT module adds control-oriented extensions: control flows, which are defined in the data dictionary; and control specifications (C-specs), which specify control-oriented processes.

C-specs describe elements that process control flows. Their child diagrams are either state-transition diagrams (STDs) or one of three matrix types: state-event matrices (SEMs), decision tables (DTs), or process-activation tables (PATs). These matrices are essentially logic tables that describe how control inputs generate control outputs.

A first pass at our sample system did not require C-specs, so I was able to describe the system adequately using only standard structured-analysis elements. RT's extensions would be most valuable for continuous-input, time-critical applications that require building sequence information into the model.

You can look at the system model from another perspective with the entity-relationship diagrams (ERDs) of Teamwork/IM. Entities and relations are defined as DFD stores in the common data dictionary; attributes are defined as data objects. This gives you a link between the ERD and the DFD through the data dictionary.

Key attributes of each entity in the data dictionary are specified with simple syntax; adding a "@" to the beginning of an attribute name designates it as a key. You can specify both logical and physical attributes (e.g., field length).

Teamwork/IM won't normalize your data model for you, but the checking facility can point out the changes that a normalized model would require. The checking facility produces helpful, clear report files, and you can also set the

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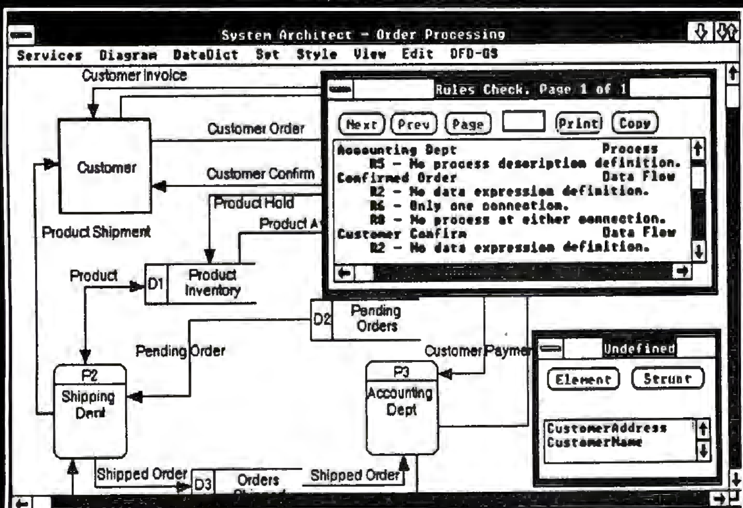
Microsoft® Windows. A user friendly standard interface, in a windowed mouse driven environment with drop down menus and pop up windows. (Chosen by IBM to be the basis for the OS/2 User Interface).

Network Version. Available with complete record and diagram locking: Novell; StarLAN; 3Com and others.



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thoroughness of each check.

Although I started with the SA tool and continued with IM, no sequence is enforced. IM generally leads you to normalized data, while SA and RT properly define your process requirements. Integration between the three analysis tools (SA, RT, and IM) is solid. You can bring up a window containing a related ERD from a store on a DFD, and you can access the dictionary entry for any diagram element from a pop-up menu. All the modules work from a single model database; you can find all occurrences of each DDE with a query facility.

One soft spot in Teamwork's integration is that elements are linked only implicitly, by name. If you change the name of an element, it loses its associated DDE and all its links.

Structured Design

The result of the analysis phase is a specification document, in the form of a single data dictionary and the various process descriptions. Teamwork's fourth module, Teamwork/SD, aids the designer in converting the specification document into a workable design.

Teamwork/SD follows the Yourdon/Constantine design methodology. It makes use of structure charts (SCs) and module specifications (M-specs), which describe how program modules relate and what functions they perform.

The designer's link between analysis and design is the data dictionary. The dictionary's store definitions define *data-only* modules in the SC, and data- and control-flow definitions define SC *couples*. All the process descriptions from the analysis phase can be viewed, but they have no link to the SC or the M-spec except through the common data dictionary. This is another of Cadre's design choices. The company believes that automatic process diagram conversion does not lead to effective designs.

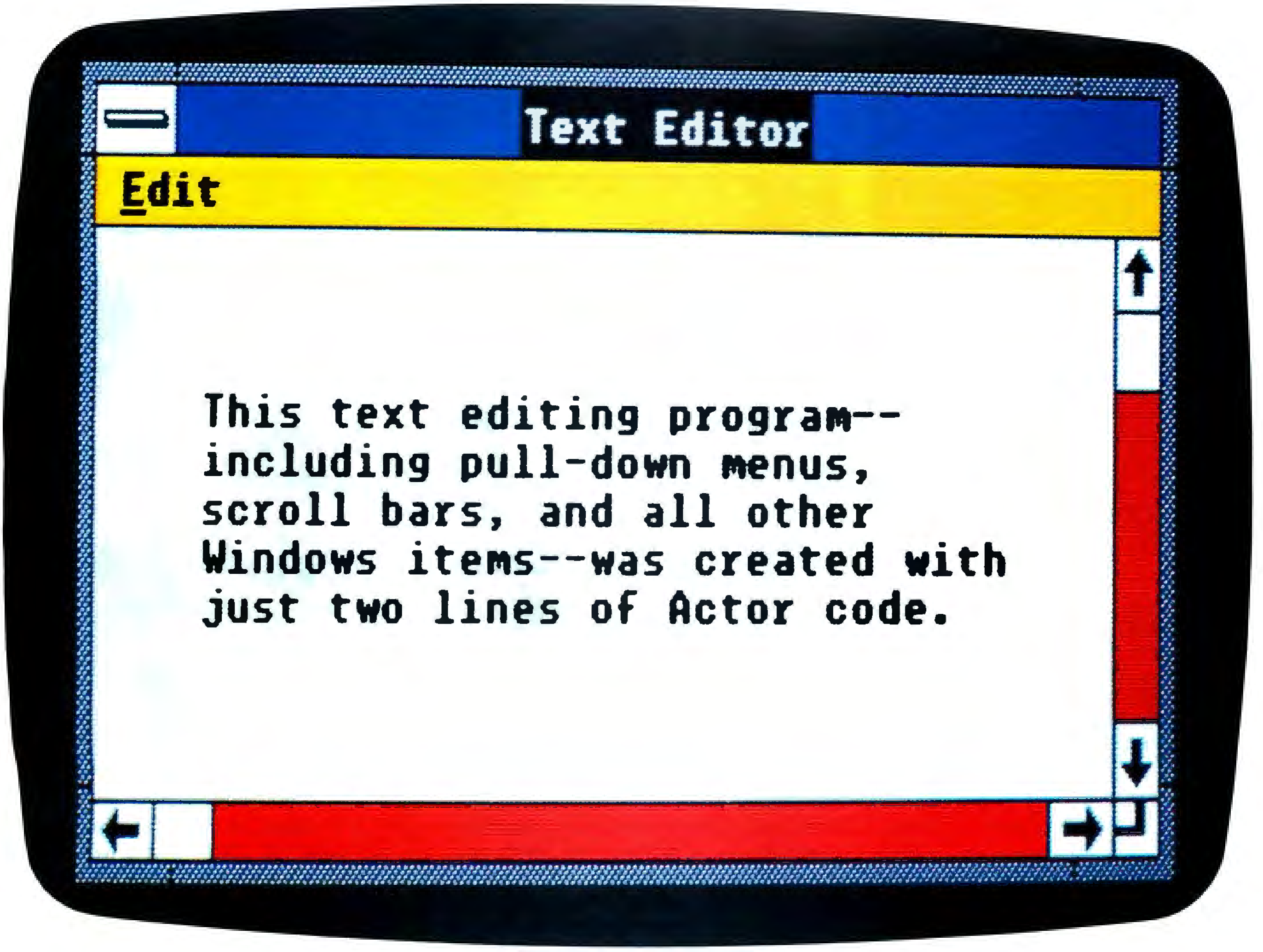
The final result of structured design is the structure chart and the M-spec that describes each module. Ideally, each module will be single-functioned and as independent as possible. Because the store definitions from the data dictionary loosely represent a database schema, both data and process descriptions can be passed to the implementation phase.

In addition to the analysis and design modules, Teamwork OS/2 also includes Cadre's IPSE toolkit. The toolkit lets you access all the entities in the Teamwork central database with external code. It also lets you customize menus in the environment. The combination lets you build in your own custom functions. Cadre offers a library of user-contributed functions written with IPSE at no charge.

There are some nice extra touches: automatic generation control, status labels for system objects, and a "baselining" facility that lets you lock in a model version are among them. There are also a few rough edges: Screen updates are not very clean, and the mouse interface runs counter to standard Macintosh, Windows, and Presentation Manager conventions.

Overall, Teamwork OS/2 is a sharp package. Multiuser support through LAN Manager will make it even sharper. Any design or analysis team with a firm background—and a firm belief—in DeMarco and Yourdon methodologies would do well to give Teamwork a close look.—*Steve Apiki*

continued



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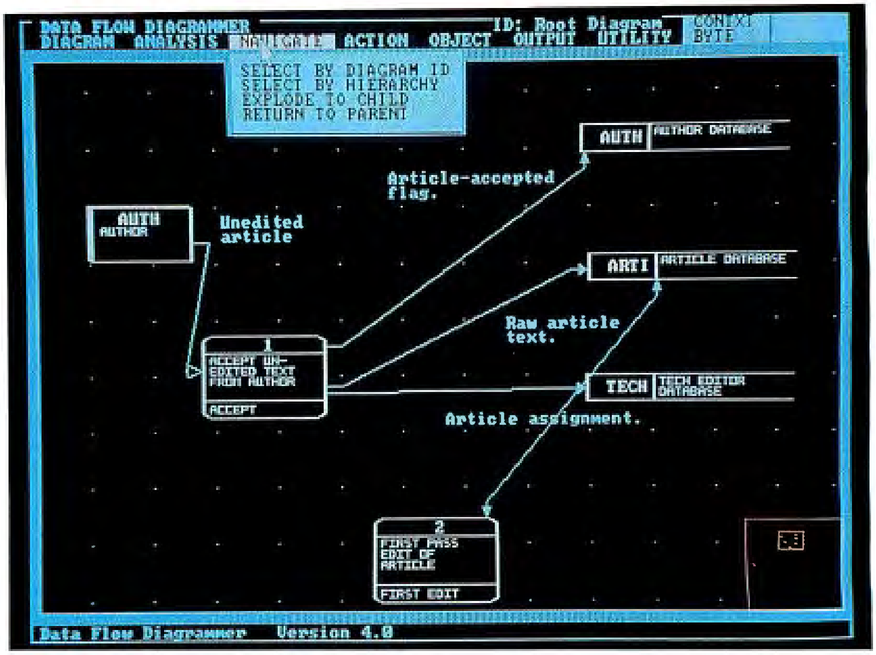
POSE

POSE's data-flow diagramer in action. Materials (in this case, an article) flow in from the external entity (an author) at left to be processed at step 1. Upon receipt of the article, data flows out of process 1 to update data stores at right.



If I may be allowed a pun, POSE (from Computer Systems Advisers) is imposing. It comes in a stack of plastic boxes—each with disks, a tutorial manual, and user's guide—that stood as high as the tower 80386 system I ran everything on. If you install the entire system, you'll need about 10 megabytes of free disk space and most of a morning.

However, one of POSE's strengths is that you don't necessarily have to buy the whole thing. In fact, the company promotes the purchasing of POSE module subsets. The nine components of POSE (which stands for Picture-Oriented Software Engineering) fall into two groups: the data method and the process method.

Members of the data method group are the data model diagramer (DMD), the data-model normalizer (DMN), the logical-database designer (LDD), and the database aid (DBA). You use these modules to design and analyze the data you need to manipulate. How that data is manipulated is left to the modules in the process method group: These modules are the data-flow diagramer (DFD), the structure-chart diagramer (SCD), the decomposition diagramer (DCD), and the action-chart diagramer (ACD).

The Data Modelers

DMD is the heart of POSE's data method modules. This is where you do your actual database design. You design graphically; entities are labeled boxes, and relationships are connecting lines anchored to the boxes by special symbols that indicate the type of relationship (e.g., one-to-many and one-to-one). You "crack open" an entity by pointing and clicking, which takes you to that entity's attributes-definition screen. Here you enter the attribute names, and a point-and-click on an attribute name takes you to a screen where you describe the details of an attribute (e.g., numeric or alphanumeric, field width, and so on).

Once you're satisfied that you have properly defined your database with DMD, it's time to normalize the database. DMN requires that you enter the functional dependencies of attributes within entities. Then you hand it your data model and push a button, and out pops a structured listing of your normalized database, along with any inaccuracies or inconsistencies that DMN was able to locate. If DMN finds errors, you have to return to DMD, fix them, and have another go at normalization.

When I first fed my model to DMN, the output showed a number of attributes tagged as foreign keys. I investigated back in DMD, and I found that I had improperly designated a pair of relations. I made the correction, reran DMN, and all was right with the world.

LDD deserves a better name. Perhaps "transaction analyzer" would be more suitable. The idea is this: Now that you have designed your database, can it support the transactions that your project will generate? Where DMD let you model the database, LDD lets you model the transactions on the database using transaction usage maps.

A TUM is a window onto a portion of the database, consisting of entities from the database connected to one another via access paths. Each access path indicates an operation on its destination entity. So, using our scenario, the transaction corresponding to logging in an article would modify the article entity, and the article entity would be connected to the contract entity by an update access path. This update path represents the modification to the author's contract data made when an article is received.

LDD's real power comes from its load analysis. As you build access paths, you set up ratios that determine how many accesses of the destination entity would be "triggered" by an access on the source entity. Using LDD, you might discover potential bottlenecks that will require optimization of the database.

When all the database analysis is done and it's time to hand your programmers something to work with, you run DBA. The DBA module generates source-code-ready schemata for a number of the more popular database systems. My system came with dBASE II, SQL/DS, ADABASE, and FOCUS.

The Process Modelers

The process-oriented modules aren't as tightly integrated as the data-oriented ones are. DCD is little more than a controlled drawing program. With DCD, you can create hierarchical diagrams of programs, data files, or even chain-of-command trees. This is a good place to organize ideas, to determine what modules you must link together to create a final program, or to build an organizational chart. But DCD doesn't communicate with the data dictionary; any graph-

ics package would do.

DFD helps you analyze how you will be using the database you designed over in DMD. Using DFD to manipulate network diagrams, you define what processes you'll need and how they fit together. Data or materials flow into a process, the process manipulates the data, and the results flow out to be worked on by subsequent processes. What you end up with is a diagram of your project's circulatory system.

It is not necessarily the case that you begin using POSE with DMD. POSE is more informal than that. You might begin by using DFD to simulate how your application works—what processes it consists of—and from that determine what data to put in your model.

SCD decomposes programs into their composite modules and diagrams the interaction between those modules. Where DFD represents sequence, SCD represents hierarchical structure.

ACD is a top-down pseudocode generator. It handles pseudocode in "brackets" that enclose procedures. There is a connection between ACD and the rest of POSE. You can create a procedure that accesses a data file by inserting a "DB-Box." The DB-Box needs to refer to one of the entities you defined way over in DMD, and, sure enough, ACD offers a menu from which you can select from a list of the entities defined there.

The Screen Report Prototyper is the module that POSE includes in both its data method and process method groups. SRP provides a means of rapidly developing prototype entry screens or reports. SRP draws information from DMD so that as you construct a screen display, you can keep track of field widths and data types. The results are handy for users and programmers alike: the mock-up gives users an idea of how data-entry screens will look when the program is complete, and programmers know what to work toward.

The POSE system is consistent. Once you're at ease working in one module, you won't have any trouble mastering the mechanics of the next module. POSE ran smoothly on my Tangent 33-MHz 80386 system, which probably favorably influenced my impression of it. Why? Because I often found myself hopping back and forth between modules, and with all that speed, there wasn't much delay. POSE may not be so swift on a 12-MHz AT. POSE would certainly benefit from a multitasking operating system like OS/2, where you could have several windows open simultaneously.

—Rick Grehan

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The key term in the phrase "computer-aided software engineering" is "aided." The current generation of CASE tools provide aid in the form of a data dictionary that describes the components of a software project as it moves through its life cycle. If you're developing a large information system, you may find that using a CASE tool to establish and maintain such a dictionary helps you to analyze the system and keep track of its components during design and implementation.

But which CASE tool? The choice hinges, primarily, on methodology—on the techniques employed to acquire and organize the information stored in the dictionary. If you already favor, say, DeMarco or DSSD methodology, you may want to look at DesignMachine or Teamwork OS/2. But if you're new to CASE, you'll need to explore the different methodologies and determine which suits your needs. Talk to practitioners. For a more complete list of CASE products, see "A CASE Workshop" in the April BYTE; the vendors listed there will put you in touch with users whose experiences you can tap.

CASE tools are expensive, but if you use one, you'll find that your investment in the underlying methodology—the cost of training and the overhead involved in applying the techniques—far outweighs the cost of the tool.

After methodology, consider your target platform. Systems oriented toward the development of mainframe COBOL applications (e.g., DesignAid, DesignMachine, IEW/WS, and Excelerator) may not be appropriate if you're developing multiuser LAN applications for the PC. A product that targets the PC, such as MicroStep, won't be much help in a mainframe environment. Again, we recommend that you talk with users engaged in projects similar to your own.

Finally, consider the phase of your design/analysis cycle that would benefit most from CASE. IEW/WS can carry you neatly from corporate philosophy to COBOL, but every user won't need every module. MicroStep, on the other hand, will limit you to the design phase.

CASE isn't magic. It's a way to help manage the complexity of large-scale information systems. The tools, like the methods they implement, aren't final solutions; they're aids. Approach the subject with reasonable expectations, and you'll benefit from the assistance that CASE tools can provide. ■

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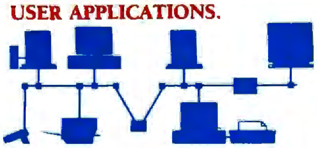

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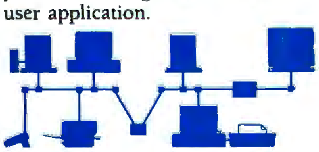

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Ram 3000 Deluxe 0-3MB Bd	89
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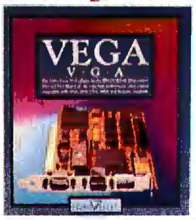

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LQ-1050 330cps, 132 Col.	Call
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Downsizing the Desktop

ADC puts the Powerlite 386 SX's petite motherboard on an add-in card

Stephen Satchell

ADC's Powerlite offers good performance in a compact, upgradable box.

The Advanced Digital Corp. (ADC) Powerlite 386 SX is at first blush just another entry into the computer sweepstakes. Closer examination, however, shows that this compact computer performs well and excels in serviceability. Its system-on-a-board design makes this Lilliputian 80386SX computer system easier to repair than systems twice as large. And when you need more computing power, you can upgrade to a new, easy-to-change system board instead of buying a whole new system.

The Powerlite currently comes in two flavors, a 20-MHz 80286-based version and a 16-MHz 80386SX-based version (ADC also plans 80386 and 80486 versions). The 80286-based systems start at $2565 and the 80386SX-based at $2795. Users with the 80286-based systems can trade in their system board and receive an 80386SX for an additional $250. I tested the 80386SX-based Model 141 with extra features that pushed the price up to $4665.

The entry-level Powerlite systems don't have mass storage devices or controllers. But both 80286 and 80386SX versions pack everything except disk drive controllers on one AT-size expansion board that plugs into a four-slot passive backplane. The system board is packed: The basic system includes a math coprocessor socket for a 10-MHz 80287 or 16-MHz 80387SX (my system included an 80387SX), 1 megabyte of zero-wait-state RAM (expandable to 2 or 5 megabytes on a piggyback card), a VGA port with 256K bytes of RAM, an RS-232C serial port, a parallel port, a keyboard port that accepts the standard IBM PS/2 keyboard or an AT keyboard with a suitable adapter, and a mouse port. ADC doesn't sell a monitor.

ADC offers two hard disk drive controller boards: a Western Digital controller and the Konan TenTime Intelligent Caching Disk Controller. My test system included the TenTime unit, which offers a 128K-byte on-board disk cache on the controller board—it doesn't use RAM on the CPU board. The Model 141 includes a 40-megabyte hard disk drive (a 100-megabyte hard disk drive is also available) and a 1.44-megabyte 3½-inch floppy disk drive. If you need to read from and write to 5¼-inch floppy disks, you can buy an external stacking chassis that can hold an optional 5¼-inch floppy disk drive and a tape backup drive.

With the controller and system boards installed, two 16-bit AT (Industry Standard Architecture) slots are left for standard AT or XT full-length expansion boards. Using an expansion board, you can extend the system RAM to 16 megabytes. The 80-watt power supply can run on either 110 or 220 volts. A switched power connector on the back lets you connect a monitor through the system power switch.

The 16-pound system unit measures 11½ inches wide by 4 inches high by 15½ inches deep; add 2 inches or so to the depth for cable clearance if you back this system up against a wall. The reset switch is in front, and the power switch is

continued

Powerlite 386 SX Model 141

Company
Advanced Digital Corp.
5432 Production Dr.
Huntington Beach, CA 92649
(800) 733-7697

Components
Processor: 16-MHz 80386SX CPU with socket for optional 16-MHz 80387SX
Memory: 1 megabyte of zero-wait-state RAM on system board, expandable to 2 or 5 megabytes via a piggyback board; 128K bytes of BIOS ROM
Mass storage: 1.44-megabyte 3½-inch floppy disk drive, 40-megabyte 28-ms hard disk drive; TenTime 128K-byte disk-cache controller
Display: VGA on motherboard
Keyboard: 101-key AT Enhanced or PS/2 style
I/O interfaces: DB-15 VGA port; RS-232C serial port with DB-9 connector; parallel port with DB-25 connector; keyboard and mouse ports; four 16-bit, full-height, ISA expansion slots (two unoccupied)

Size
11½ × 4 × 15½ inches; 16 pounds

Software
System utilities disk

Documentation
User's guide; technical reference guide; TenTime manual

Price
$2795
System as reviewed: $4665

Inquiry 851.

located on the rear panel.

ADC supplies a RAM disk, a print spooler, and disk-cache software with every system. For systems with the TenTime disk controller, ADC also provides setup, configuration, and tuning utilities for the controller board.

The Powerlite is strictly an office machine; the unit I tested met FCC Class A (commercial) regulations instead of the more stringent Class B (residential) limits for radio frequency emissions.

Setup

Setup is a breeze. All the programs for setting up the CPU board and hard disk drives connected to the Western Digital controller are built into the BIOS—there is no setup disk. The TenTime board has its utilities on disk, though, and you must have MS-DOS to run them, even if you plan to use a different operating system. Jumpers and switches on the CPU board let you configure the VGA adapter and mouse ports; the configuration for the serial and parallel ports is fixed.

Expansion boards slip in horizontally (see photo 1). The left side of the system unit frame is hinged; you remove one screw and loosen another, and the side swings down. You can then remove the filler plate and install the board.

I don't recommend placing the monitor directly on top of the system unit. The battery connector, in particular, and several other connectors stand too high on the CPU board, hitting the top of the case when the system is assembled. After a few months of use, this could cause problems (I put electrical tape on the underside of the cover to prevent trouble). If you're tight for space, consider constructing a monitor platform to keep the monitor off the system cover, or move the CPU board down one slot and sacrifice the top backplane slot.

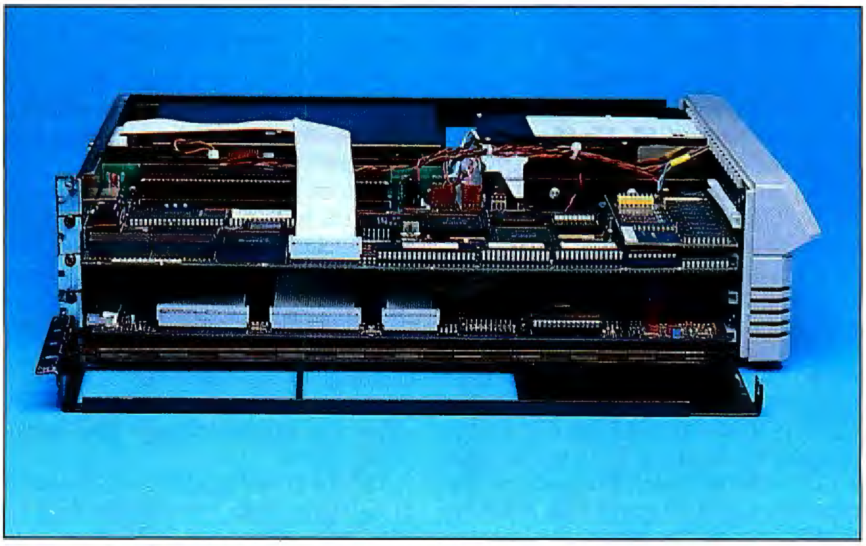


Photo 1: *The Powerlite motherboard, mounted in one of four passive backplane expansion slots, is easy to service. A hinged door on the side of the case ensures easy access. A Konan disk drive controller board occupied the bottom slot in my test unit.*

Test Run

The standards for IBM PC clone making are well enough defined that you don't expect to find many programs that don't work. The Powerlite 386 is no exception. Not only did the machine work flawlessly with the standard applications benchmark suite, but it also worked with many of the old standbys, like Crosstalk XVI 3.60 and Lotus 1-2-3 release 1A. I also tried a smattering of other applications, such as SideKick 1.56A, Professional YAM 17.28, Smartcom III 1.1, XTree-Pro 1.1, and LapLink Mac 1.2. I successfully ran IBM's PC-DOS 3.2 and PC-DOS 3.3.

My ancient Hayes 1200B internal modem wouldn't fit into a 16-bit slot, so I couldn't test 8-bit bus access using a modem. I did use an AST RAMpage AT card with 2 megabytes of memory to look at 16-bit access, though, and I encountered no problems.

In BYTE's benchmark testing, the Powerlite's overall performance was significantly better than that of the IBM PS/2 Model 55 SX and was neck-and-neck with the Compaq 386s. The Powerlite's one weak spot was video: It lost to both competitors in the text portion of the low-level Video tests and in the Scientific/Engineering application tests.

In the low-level tests, the Powerlite came out ahead of the Compaq in CPU performance. But while the ADC cache controller put the Powerlite far ahead of the Compaq in most low-level Disk I/O tests, the Compaq with its 40-megabyte ESDI hard disk drive outperformed the Powerlite by large margins in the large-file tests. The Compaq also edged out the Powerlite in the LINPACK and Livermore Loops tests.

Fit and Finish

The designer who masterminded the Powerlite's CPU board certainly did a beautiful job. There's more open space on a postage stamp than there is on this board. In fact, the board is so packed with chips that ADC had to use surface-mounted resistors and capacitors on the reverse side of the board.

Unfortunately, the height of some connectors makes the board fit tightly into the case, and the backplane is hard-wired into the power supply, so if you have

continued

ADC Powerlite 386 SX

APPLICATION-LEVEL PERFORMANCE

WORD PROCESSING

XyWrite III+ 3.52	**Medium/Large**
Load (large)	:05
Word count	:04/:27
Search/replace	:06/:22
End of document	:02/:11
Block move	:11/:10
Spelling check	:11/1:24
Microsoft Word 4.0	
Forward delete	:19
Aldus PageMaker 1.0a	
Load document	:13
Change/bold	:32
Align right	:24
Cut 10 pages	:22
Place graphic	:05
Print to file	1:50
Index:	**2.38**

SPREADSHEET

Lotus 1-2-3 2.01	
Block copy	:04
Recalc	:02
Load Monte Carlo	:17
Recalc Monte Carlo	:07
Load rlarge3	:04
Recalc rlarge3	:01
Recalc Goal-seek	:04
Microsoft Excel 2.0	
Fill right	:07
Undo fill	2:49
Recalc	:02
Load rlarge3	:31
Recalc rlarge3	:01
Index:	**2.25**

DATABASE

dBASE III+ 1.1	
Copy	:25
Index	:08
List	2:59
Append	:46
Delete	:03
Pack	:47
Count	:07
Sort	:31
Index:	**2.48**

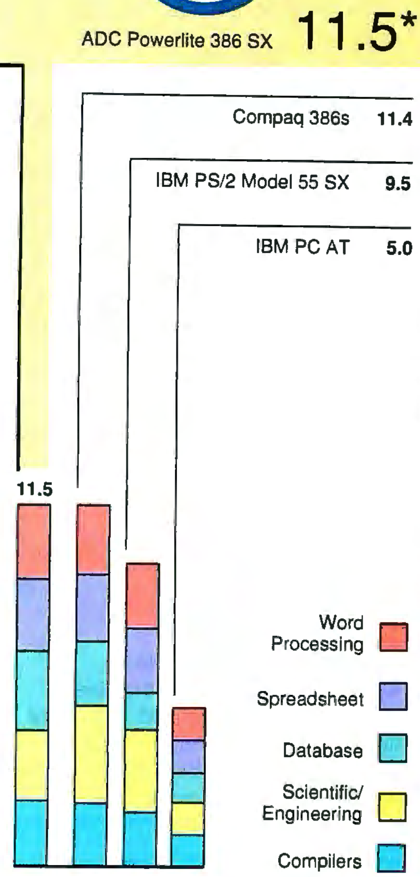
SCIENTIFIC/ENGINEERING

AutoCAD 2.52	
Load SoftWest	1:00
Regen SoftWest	:52
Load StPauls	:12
Regen StPauls	:07
Hide/redraw	15:49
STATA 1.5	
Graphics	2:17
ANOVA	:23
MathCAD 2.0	
IFS 800 pts.	:22
FFT/IFFT 1024 pts.	:25
Index:	**2.24**

COMPILERS

Microsoft C 5.0	
XLisp compile	4:39
Turbo Pascal 4.0	
Pascal S compile	:05
Index:	**2.13**

All times are in minutes:seconds. Indexes show relative performance; for all indexes, an 8-MHz IBM PC AT=1.



*Cumulative application index. Graphs are based on indexes at left and show relative performance.

LOW-LEVEL PERFORMANCE[1]

CPU

Matrix	6.66
String Move	
Byte-wide	50.92
Word-wide:	
Odd-bnd.	42.24
Even-bnd.	25.43
Doubleword-wide:	
Odd-bnd.	27.48
Even-bnd.	19.26
Sieve	32.90
Sort	31.54
Index:	**1.92**

FLOATING POINT

Math	11.53
Error[2]	
Sine(*x*)	3.29
Error	
e^x	3.64
Error	
Index:	**4.88**

DISK I/O

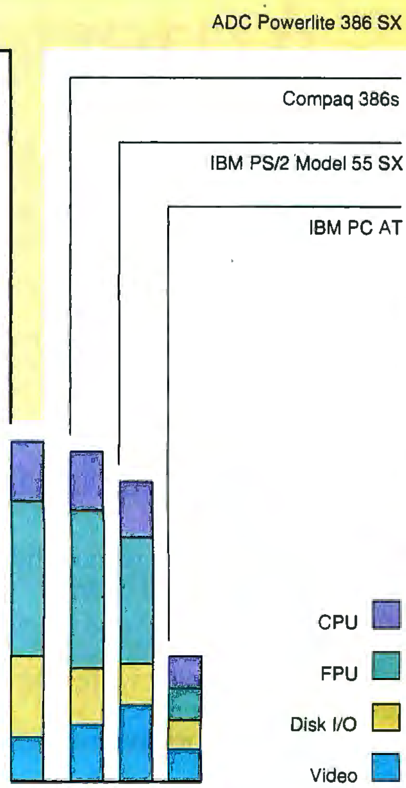
Hard Seek[3]	
Outer track	0.55
Inner track	0.53
Half platter	0.57
Full platter	0.51
Average	0.54
DOS Seek	
1-sector	1.82
32-sector	47.61
File I/O[4]	
Seek	0.13
Read	0.90
Write	0.72
1-megabyte	
Write	6.55
Read	5.36
Index:	**2.64**

VIDEO

Text	
Mode 0	12.49
Mode 1	12.43
Mode 2	12.48
Mode 3	12.49
Mode 7	N/A
Graphics	
CGA:	
Mode 4	1.69
Mode 5	1.67
Mode 6	1.76
EGA:	
Mode 13	3.07
Mode 14	3.33
Mode 15	N/A
Mode 16	3.33
VGA:	
Mode 18	3.48
Mode 19	1.79
Hercules	N/A
Index:	**1.37**

CONVENTIONAL BENCHMARKS

LINPACK	254.80
Livermore Loops[5] (MFLOPS)	0.1123
Dhrystone (MS C 5.0) (Dhry./sec.)	3825



N/A=Not applicable.

[1] All times are in seconds. Figures were generated using the 8088/8086 and 80386 versions (1.1) of Small-C.

[2] The errors for Floating Point indicate the difference between expected and actual values, correct to 10 digits or rounded to 2 digits.

[3] Times reported by the Hard Seek and DOS Seek are for multiple seek operations (number of seeks performed currently set to 100).

[4] Read and write times for File I/O are in seconds per 64K bytes.

[5] For the Livermore Loops and Dhrystone tests only, higher numbers mean faster performance.

For a full description of all the benchmarks, see "Introducing the New BYTE Benchmarks," June 1988 BYTE.

problems in one, you'll probably have to replace them both. Overall, however, the workmanship in the Powerlite is far above average for a PC clone. ADC backs the machine with a one-year warranty.

This is one of the easiest computers to fix that I've seen. Since the CPU is on an expansion board, it's easy to pop out and exchange. The trend toward putting I/O ports on the system board means that if you blow a port, you've blown the system board—which in most systems is a pain to replace. There's no pain in replacing the system board in the Powerlite. If you can install an add-in card, you can replace the system board in this machine.

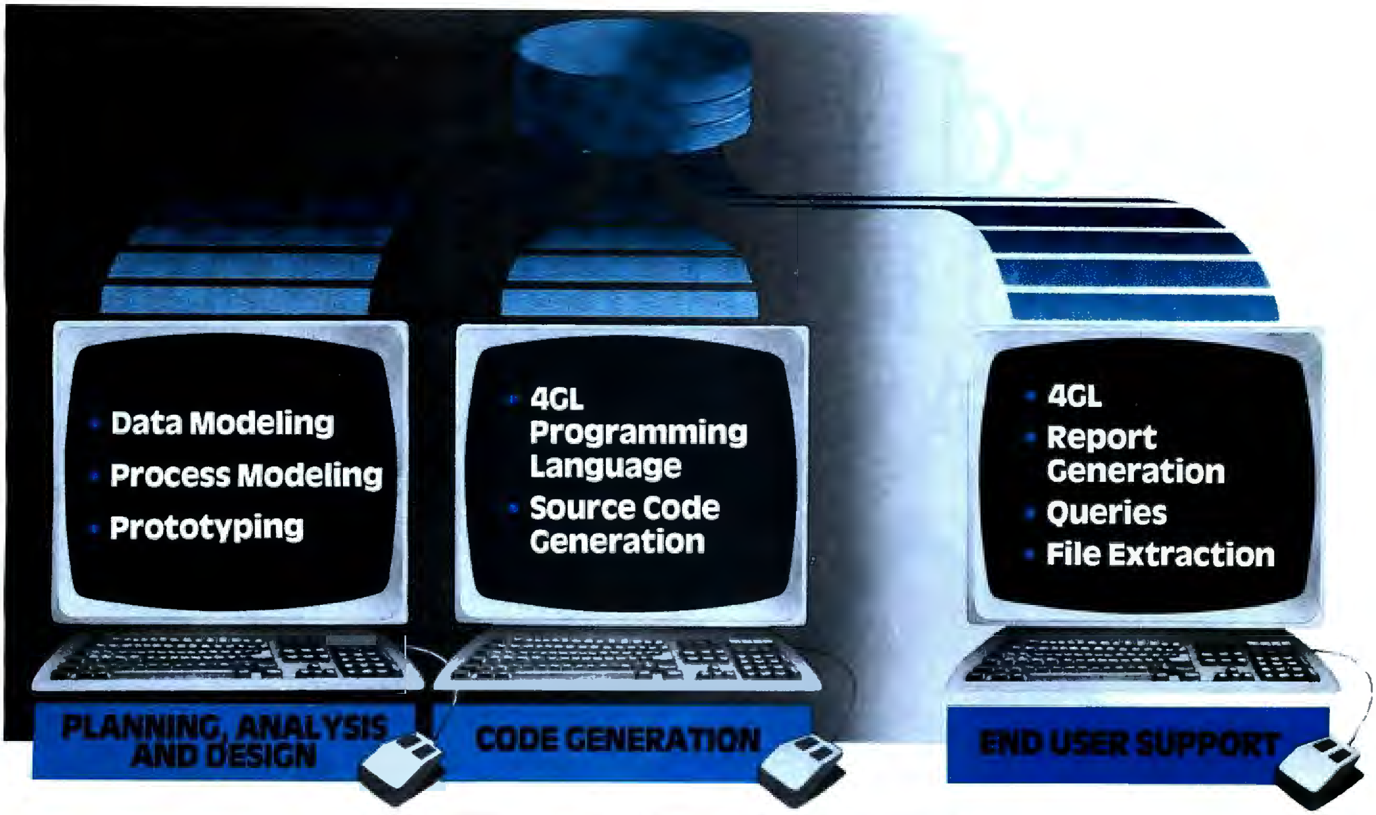
Documentation consists of three manuals: the user's guide, the technical reference guide for the CPU board, and the TenTime manual. The user's guide and technical reference manuals are well written and organized; the TenTime manual was marked "preliminary." Troubleshooting information is incomplete: While trying to get the system to work the first time, I kept getting code signals from the speaker. But ADC's technical support was good; it has a toll-free number, and its technicians did a fine job helping me with some of the strange behavior the Powerlite exhibited after some heavy-handed treatment during shipping.

Value

When you compare the retail prices of the Powerlite 386 SX to the two industry leaders—the IBM PS/2 Model 55 SX and the Compaq 386s—you'll find little difference. My Powerlite 386 SX Model 141 was $4665. The Model 140, which substitutes the Western Digital controller for the TenTime, is $3955. Compare that to a similarly equipped Compaq Model 40 ($4199) or an IBM Model 55 SX, which for $3895 comes with a 30-megabyte hard disk drive and 2 megabytes of RAM.

The Powerlite gives you at most two available slots; the Compaq and IBM systems can take up to three cards. If you have extra RAM, an internal modem, and a network card, you're out of luck with the Powerlite. But in an office environment where space is at a premium and serviceability is important, this machine is one of the best choices I've seen. ■

Stephen Satchell has evaluated computer products for 17 years. His company, Satchell Evaluations in Incline Village, Nevada, tests microcomputer hardware and software. He can be reached on BIX as "ssatchell."



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Circle 326 on Reader Service Card (DEALERS: 327)

Upscale Acer

Acer's high-performance 1100/33 enters the 33-MHz fray

Jeff Holtzman

Personal computers based on Intel's 33-MHz 80386 CPU have flooded the market. They're fast, expensive, and available from just about every clone maker on the market. But they're not all the same—prices and quality vary—and they're not for everyone. Acer America's entry in this increasingly crowded field attempts to bring users high performance at a moderate price.

Acer's $7895 base model comes with everything you need to run DOS except a video subsystem and a hard disk drive. It includes 4 megabytes of RAM, a 1.2-megabyte 5¼-inch floppy disk drive, two serial ports, a parallel port, a floppy/hard disk drive interface, a keyboard and mouse, a socket for an 80387 or Weitek math coprocessor, space for five half-height mass-storage devices, DOS 3.3, GWBASIC 3.3, Windows/386, a disk-cache utility, and an EMS emulator. My test system also included an Intel 80387 ($700), an 8-bit VGA board ($1005), a 150-megabyte Micropolis ESDI hard disk drive and controller ($1675), 4 more megabytes of RAM ($2000), and a copy of OS/2 1.0 ($325), bringing the grand total to $13,600.

The floppy/hard disk drive interface card is an Acer design and accepts up to two floppy disk drives and a hard disk drive. Acer includes the parallel and serial I/O circuitry on the motherboard.

The motherboard accepts 4 or 8 megabytes of 80-nanosecond, 1-megabyte page-mode single in-line memory modules (SIMMs); you can expand the system to a total of 24 megabytes of memory using the machine's two 32-bit expansion slots. The memory subsystem includes a nonexpandable 32K-byte 20-ns static RAM cache with an Intel 82385 controller.

The 1100/33 includes eight expansion slots: one standard 8-bit slot, five standard 16-bit slots, one 32-bit slot for memory, and one slot that can function as either a standard 16-bit slot or an additional 32-bit slot. That gives you a total of seven standard slots. In my review system, the video, floppy disk drive interface, and ESDI hard disk drive controller cards used three slots, leaving four for other expansion options. However, considering that the I/O ports and as much as 8 megabytes of memory can fit on the motherboard, four free slots shouldn't be too limiting.

Construction

The quality of construction in my test machine was disappointing. The first machine I received was unreliable and eventually refused to boot at all. Acer quickly replaced it with another unit. This one worked properly; to make sure, I kept it running 24 hours a day for several weeks. Neither unit I tested looked finished; both had a dozen or so engineering-change wires on both sides of the system board. In the first unit, those wires were attached quite sloppily; in the

continued

Acer 1100/33

Company
Acer America Corp.
401 Charcot Ave.
San Jose, CA 95131
(408) 922-0333

Components
Processor: 33-MHz 80386; socket for 33-MHz 80387 coprocessor
Memory: 4 megabytes of 32-bit 80-ns DRAM SIMMs; 32K bytes of 20-ns SRAM cache
Mass storage: 1.2-megabyte 5¼-inch floppy disk drive; 150-megabyte hard disk drive
Display: Acer 8-bit VGA adapter; multiscan monitor
Keyboard: 101-key PS/2 compatible
I/O interfaces: 9-pin serial port; 25-pin serial port; 25-pin parallel port; slots: one 8-bit, five 8-/16-bit, one 16-/32-bit, and one 32-bit

Size
7 by 17 by 21 inches; 50 pounds

Software
MS-DOS 3.3; GWBASIC 3.3; Microsoft Windows/386 2.1; disk-cache utility; EMS emulator

Documentation
User's manual; MS-DOS manual; GWBASIC manual; Microsoft Windows/386 manual; disk-cache utility manual

Price
Base system: $7895
System as reviewed: $13,600

Inquiry 862.

second, the soldering was neater and the wires were glued to the board.

The 1100/33 comes in a standard desktop configuration; you open it by removing five screws from the rear panel. The interior follows the standard AT layout, with the 230-watt power supply in the right rear corner, the drive bays in front, and the motherboard on the left.

At about 12 by 14 inches, the motherboard is fairly large, containing perhaps 40 percent more surface area than typical AT and 80386 motherboards. But that space isn't wasted; it includes the SIMM panels, the serial and parallel I/O circuitry, two Award BIOS EPROMs, the cache memory, and many discrete logic chips. It also contains several jumper blocks and DIP switches, and one block of DIP switches is accessible through a small hatch on the rear of the chassis.

The jumpers and switches set operating parameters (e.g., the type and the amount of memory, and the presence of a coprocessor). One switch setting enables shadow RAM so that the system BIOS and the video BIOS can run from RAM. A system utility lets you enable and disable shadow RAM on the fly; that utility also lets you switch to an 8-MHz compatibility speed and to disable the cache. A hot-key combination also lets you switch between 8- and 33-MHz operation.

The Acer 1100/33 uses a 101-key, PS/2-compatible keyboard. The keys produce tactile and audible feedback, but they are a little wobbly. The 14-inch multiscan monitor has front-mounted brightness and contrast controls; the vertical size control and the horizontal and vertical position controls are on the back. The CRT image is clean and stable and has a maximum resolution of 600 by 800 dots per inch.

The 1100/33's front panel has a standard keyboard interlock, LEDs to indicate hard disk activity and operating speed, and reset and power switches. The hard disk and floppy disk drives are not secured by screws; instead, they are press-fit into place by flat metal springs. Although this method seems less secure, the springs hold the drives firmly in place.

Acer's documentation is brief and well written and contains such technical information as memory and I/O port address maps, listings of interrupts and direct-memory-access channels, and port pin-outs.

Acer has a good warranty policy: For the first four months after purchase, the company provides guaranteed next-business-day on-site repair or replacement; for the next eight months, no-charge depot service (the customer pays one-way shipping). You can extend the warranty for $99 per year.

Compatibility Tests

The 1100/33 worked well with everything I tested. On the hardware side, I had no trouble running either the Microsoft-compatible mouse that came with the system or a Microsoft Serial Mouse. A Hayes 2400-bps internal modem also worked fine, as did an Irwin 785 tape backup unit and a Corvus ReadyNet network interface card.

As for software, I ran WordStar 5.5, XyWrite III Plus 3.55, Qedit 2.07, Q&A Write 1.01, Lotus 1-2-3 release 2.01, VP-Planner 1.0, AutoSketch 1.04 enhanced, SideKick 1.56b, Windows/386, Acer's dual-boot version of OS/2 1.0, Turbo Pascal 5.0, 386Max 4.07, OmniView 4.13, GrandView 1.01, KeepTrack Plus 2.0, and Procomm Plus 1.1A. I also tested LapLink III, which worked reliably only at the 8-MHz compatibility speed.

Performance

The 1100/33 has an extremely fast CPU subsystem; in fact, of all the machines in its class that BYTE has tested, only the Everex Step 386/33 and the ALR FlexCache 33/386 Model 150 surpass the Acer (see "Megahertz Madness," *IBM Special Edition*, Fall 1989). Unfortunately, the other subsystems don't live up to the standard set by the Acer's CPU performance, and that keeps the Acer near the bottom of the pack in most other categories.

The Acer 1100/33's FPU index was marginally lower than those of the Compaq Deskpro 386/33 and the Everex 386/33. It was also slower, by about 25 percent, than the Compaq in the low-level disk tests. The Acer's poorest showing was on the video benchmarks; it was less than half as fast as the Compaq and Everex systems.

Based on the low-level benchmarks, it's not surprising that the Acer 1100/33 also scored lower than the Compaq Deskpro 386/33 and the Everex 386/33 in most of the applications tests; its applications index of 20.3 puts it in twelfth place among the 15 33-MHz systems that BYTE has tested to date.

Deciding Factors

The 1100/33 is one of the more expensive 33-MHz machines that BYTE has reviewed. It prices well against the Compaq but lags behind it in terms of quality of construction. Other clone makers offer similarly configured machines for substantially less. A 386/33 from PC Link, for example, includes the same amount of RAM, a 115-megabyte ESDI hard disk drive, and a 16-bit VGA adapter for $5995.

Better yet, you might want to look into the new crop of 25-MHz 80486-based systems, which should be available by the time you read this. Because the 80486 includes memory management and FPU functions on a single chip, 80486-based systems could be only slightly more costly than the current crop of 33-MHz 80386 systems, and the BYTE benchmarks run on prototype 80486 systems indicate that they will perform much faster, particularly in number-crunching applications. ■

Jeff Holtzman is a freelance writer and an analyst at Unisys Corp. He can be reached on BIX as "jholtzman."

Acer 1100/33

Acer 1100/33 **20.3***

APPLICATION-LEVEL PERFORMANCE

WORD PROCESSING

XyWrite III + 3.52	Medium/Large
Load (large)	:12
Word count	:02/:09
Search/replace	:03/:13
End of document	:01/:08
Block move	:08/:07
Spelling check	:05/:29
Microsoft Word 4.0	
Forward delete	:10
Aldus PageMaker 1.0a	
Load document	:06
Change/bold	:15
Align right	:11
Cut 10 pages	:12
Place graphic	:03
Print to file	1:41
Index:	**4.10**

SPREADSHEET

Lotus 1-2-3 2.01	
Block copy	:02
Recalc	:01
Load Monte Carlo	:14
Recalc Monte Carlo	:02
Load rlarge3	:03
Recalc rlarge3	:01
Recalc Goal-seek	:02
Microsoft Excel 2.0	
Fill right	:02
Undo fill	:55
Recalc	:01
Load rlarge3	:15
Recalc rlarge3	:01
Index:	**4.16**

DATABASE

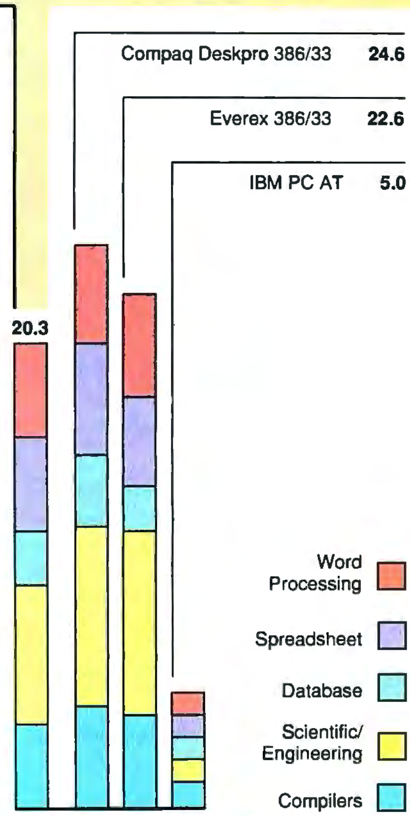
dBASE III + 1.1	
Copy	:32
Index	:07
List	:46
Append	1:26
Delete	:02
Pack	1:12
Count	:11
Sort	:59
Index:	**2.33**

SCIENTIFIC/ENGINEERING

AutoCAD 2.52	
Load SoftWest	:25
Regen SoftWest	:18
Load StPauls	:07
Regen StPauls	:03
Hide/redraw	5:22
STATA 1.5	
Graphics	:30
ANOVA	:10
MathCAD 2.0	
IFS 800 pts.	:08
FFT/IFFT 1024 pts.	:08
Index:	**6.03**

COMPILERS

Microsoft C 5.0	
XLisp compile	2:23
Turbo Pascal 4.0	
Pascal S compile	:03
Index:	**3.69**



*Cumulative application index. Graphs are based on indexes at left and show relative performance.

All times are in minutes:seconds. Indexes show relative performance; for all indexes, an 8-MHz IBM PC AT=1.

LOW-LEVEL PERFORMANCE[1]

Acer 1100/33

CPU

Matrix	2.05
String Move	
Byte-wide	12.66
Word-wide:	
Odd-bnd.	16.43
Even-bnd.	6.34
Doubleword-wide:	
Odd-bnd.	12.47
Even-bnd.	3.17
Sieve	10.53
Sort	8.02
Index:	**6.60**

FLOATING POINT

Math	3.52
Error[2]	
Sine(x)	1.15
Error	
e^x	1.21
Error	
Index:	**14.84**

DISK I/O

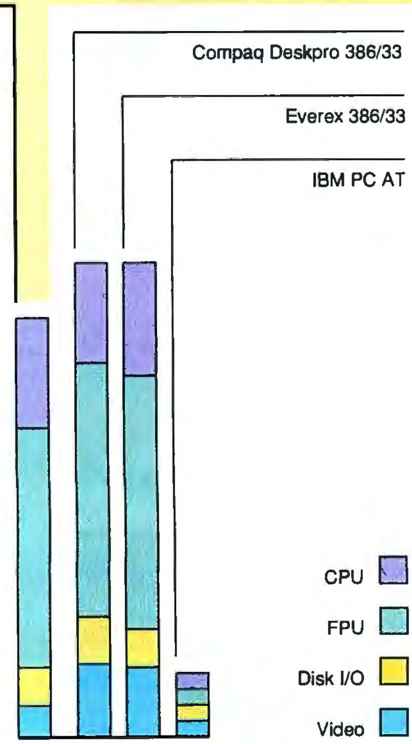
Hard Seek[3]	
Outer track	3.33
Inner track	3.32
Half platter	6.68
Full platter	10.00
Average	5.83
DOS Seek	
1-sector	11.99
32-sector	21.98
File I/O[4]	
Seek	0.03
Read	0.92
Write	0.80
1-megabyte	
Write	2.91
Read	4.43
Index:	**2.29**

VIDEO

Text	
Mode 0	7.95
Mode 1	7.94
Mode 2	7.74
Mode 3	7.75
Mode 7	N/A
Graphics	
CGA:	
Mode 4	1.02
Mode 5	1.02
Mode 6	1.08
EGA:	
Mode 13	2.56
Mode 14	2.71
Mode 15	N/A
Mode 16	2.71
VGA:	
Mode 18	2.80
Mode 19	0.99
Hercules	N/A
Index:	**2.01**

CONVENTIONAL BENCHMARKS

LINPACK	99.20
Livermore Loops[5] (MFLOPS)	0.3236
Dhrystone (MS C 5.0) (Dhry./sec.)	11,111



N/A = Not applicable.

[1] All times are in seconds. Figures were generated using the 8088/8086 and 80386 versions (1.1) of Small-C.

[2] The errors for Floating Point indicate the difference between expected and actual values, correct to 10 digits or rounded to 2 digits.

[3] Times reported by the Hard Seek and DOS Seek are for multiple seek operations (number of seeks performed currently set to 100).

[4] Read and write times for File I/O are in seconds per 64K bytes.

[5] For the Livermore Loops and Dhrystone tests only, higher numbers mean faster performance.

For a full description of all the benchmarks, see "Introducing the New BYTE Benchmarks," June 1988 BYTE.

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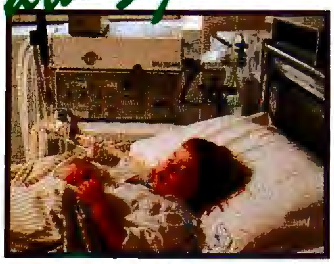

Courtesy Siemens Life Support Systems.

- industrial robotics-control environments, where multiple numerical or assembly-line machines can be centrally controlled

Process Control

Courtesy Ford Motor Company.

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Courtesy Hugin Sweda.

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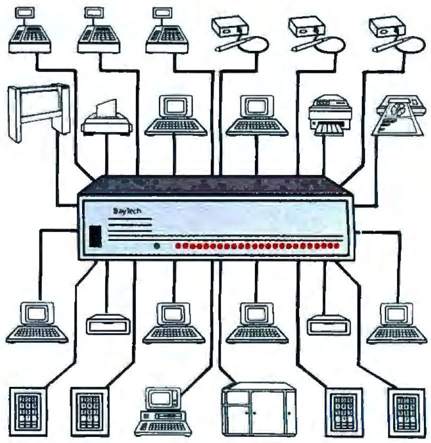

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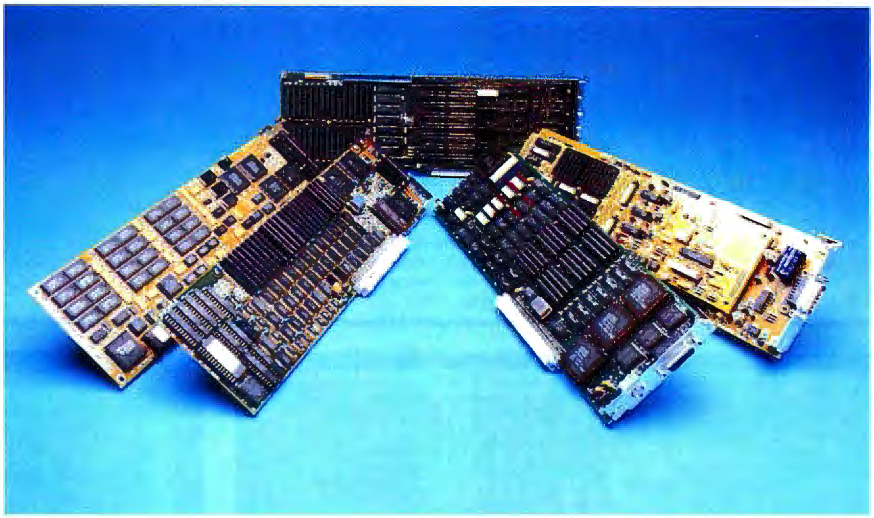
Circle 35 on Reader Service Card (DEALERS: 36)

How to Put 16 Million Colors to Work

Similarity reigns among the first video and video-graphics boards for 32-Bit QuickDraw

Tom Thompson



Clockwise from top: Truevision NuVista 4M, Data Translation ColorCapture, SuperMac Spectrum/24, Radius DirectColor/24, and RasterOps ColorBoard 224.

What a difference five years make, especially for the Macintosh. Back when the Mac consisted of just a small black-and-white monitor and little color support, critics asked, "Why doesn't the Mac have color?" Apple not only provided color but, early this year, also introduced 32-Bit QuickDraw (see "Apple's 32-Bit QuickDraw Covers the Spectrum," July BYTE). This enhancement to Color QuickDraw lets Macs handle 16-bit pixels (actually using 15 bits for color information, for a range of 32,767 colors) or 32-bit pixels (using 24 bits for color information, for a range of 16,777,216 colors). So, now that the Mac accommodates millions of colors, the question has become, "What can you do with that many colors?"

Video and video-graphics boards have now arrived to answer this question. I looked at two categories of NuBus boards for the Mac II family: those that display 24-bit color (remember, only 24 bits out of the 32-bit pixel contain color data), and those that capture and manipulate video images.

Well-Equipped Macs

Thanks to these NuBus boards, a properly equipped Mac can now tackle imaging jobs that, formerly, only workstations or minicomputers could handle. What constitutes a properly equipped Mac? First, it must be either a Mac II–family system or a Mac SE/30 with at least 2 megabytes of RAM. Only the Mac IIci contains 32-Bit QuickDraw in its ROM, so the other Macs require System 6.0.3 and a special patch file that's installed at boot time.

Although 32-Bit QuickDraw does a pretty fair job dithering a "deep" image (images using 16- or 32-bit pixels) to accommodate an 8-bit pixel screen, you'll need a video board that can display deep colors for 16-million-color image processing. If you plan to work with your own images, you'll need to have either a color scanner (see "Full-Spectrum Scanners," April BYTE) or some other image-capturing device.

Buckets of Colors

In the first category of NuBus boards, SuperMac Technology's Spectrum/24, RasterOps' ColorBoard 224, and Radius's DirectColor/24 not surprisingly shared many features (see table 1). All came with disks that supplied the required System 6.0.3 and the 32-Bit QuickDraw patch file. I used the boards on a Mac II with 5 megabytes of RAM and on a Mac IIcx with 4 megabytes of RAM.

Both the Spectrum/24 and the DirectColor/24 can operate without 32-Bit QuickDraw installed. That is, you can plug in the board and restart the Mac, and the Mac Desktop will appear on the monitor, although you won't be able to set the screen mode deeper than 8 bits. This isn't the case for the ColorBoard 224: Without 32-Bit QuickDraw, the Mac boots, but the monitor remains dark. If your Mac uses only this board for video, you'll need to set up a boot floppy disk with 32-Bit QuickDraw to install the software and recover from system crashes.

Each board comes with an additional one or two cdev files that provide special features. For example, the Spectrum/24's `SuperVideo` cdev and the ColorBoard 224's `CB 224-II` cdev both allowed me to zoom and pan. These features come in handy if you're creating detailed artwork or CAD and need to view a close-up section of the image.

continued

Table 1: *Subtle features distinguish the initial entrants in the 24-bit color video board market.*

24-BIT COLOR BOARDS

Board	Screen mode (bits/pixel)	Screen size supported	Pixel clock (MHz)	Refresh rate (Hz)	Zoom	Pan	Upgrade board?[1]	Expanded desktop[2]	Other features
Spectrum/24	1, 2, 4, 8, 24	640 × 480[3] 1024 × 768	30.24 64	66.7 60	2×	Yes	No	4096 × 1536	Home cursor; center dialogs; optional oscillator drives; multiscan or NTSC displays
ColorBoard 224	1, 2, 4, 8, 24	640 × 480 800 × 600 1024 × 768	30.24 50 64	66.7 66.7 60	2×, 4×	Yes	No	4096 × 1024	Center dialogs; pop-up menus; adjust pan border and rate; board switches set screen size
DirectColor/24	1, 8, 16, 24	1152 × 882	100	72	N/A	No	Yes	N/A	Center dialogs; tear-off menus; enlarged menu font; pop-up screen bit-depth changer; cursor locator; adjustable windows for enlarged menu bar; zoom box; options for multiple monitors; screen saver; screen capture

[1] DirectColor/16 board displaying 16-bit colors accepts additional video RAM to convert board to a DirectColor/24.
[2] Maximum size given, with screen in 1-bit mode (2-bit mode for ColorBoard). Expanded desktop is at the expense of pixel depth—that is, the larger the expanded desktop, the fewer colors that can be displayed. Smaller expanded desktop configurations are possible, using more colors.
[3] Must change oscillator on board to use this screen size.

Output from the Spectrum/24 (top left), DirectColor/24 (top right), and ColorBoard 224 (bottom right) video boards. These boards use 32-Bit QuickDraw to display as many as 16.7 million colors. The Spectrum/24 accommodates both Apple's MacsBug and ICOM Simulations' TMON debuggers, making it a good choice for software development work. It's also the least expensive of the the three boards. DirectColor/24, when teamed with its two-page monitor, is a candidate for color desktop publishing and CAD/CAM. The ColorBoard 224 supports several display sizes. Its CB 224-II *cdev provides zoom and pan features helpful to those who create detailed artwork or CAD images.*

Table 2: *Video-graphics boards feature image input and output choices.*

VIDEO-GRAPHICS BOARDS

Board	Image capture size (pixels)[1]	Output image format	Output image depth (max.)	Video input	Video output	Genlock display?	Act as Mac mode (bits)	Serves as Mac video board	Zoom[2]
ColorCapture	640 × 480 NTSC, 512 × 768 PAL[3]	TIFF (24-bit), IMAGE[4]	16-bit	NTSC, PAL[3]	RGB, NTSC,[5] PAL[3]	Yes	No	N/A	2×-10×
NuVista 4M	756 × 485 NTSC, 768 × 575 PAL	TGA (32-bit), PICT	32-bit	RGB[6]	RGB[5]	Yes	Yes	1, 2, 4, 8, 16, 32	2×, 4×, 8×, 16×

[1] Maximum capture size; can be varied.
[2] For the ColorCapture, zoom applies to examination of captured image. For the NuVista, zoom applies to the Mac display, which can include the captured image.
[3] Requires different version of ColorCapture board.
[4] Proprietary format.
[5] Composite.
[6] Requires a separate video encoder/decoder unit to handle NTSC and PAL video.

The DirectColor/24's `II Display` cdev provides tear-off menus (the ColorBoard 224 provides pop-up menus), a screen saver, and a screen-capture function. The screen capture is an asset because it allows you to import 16- or 32-bit images to a PICT file. For example, you might run an application simulating complex turbulence flow on a mainframe and then capture the plotted image to a file from the Mac's screen.

If you must change to a different or larger monitor, both the Spectrum/24 and the ColorBoard 224 support several display sizes. However, the Spectrum/24 requires a ticklish oscillator swap that includes prying a component off the video board and plugging in a new one; the ColorBoard 224 manages this feat with a set of switches. The Spectrum/24's advantage is that you can add optional oscillators to drive different monitors, such as a multiscan or National Television System Committee (NTSC) RGB monitor.

The DirectColor/24 drives only a Radius Color Display, an impressive 19-inch monitor with a 1152- by 882-pixel, 82-dot-per-inch screen. The $4295 Color Display simultaneously shows two letter-size pages, making it valuable for desktop publishing. Because these pages are in 24-bit color, the DirectColor/24 and Color Display combination also suits color prepress applications.

Deep pixels and large screens make for lots of data for the Mac to draw, so the boards draw screens slower than 8-bit boards do. Fortunately, Apple optimized 32-Bit QuickDraw's graphics routines for speed so that the drawing rates are reasonable. However, Radius is also shipping an accelerator board that boosts the execution speed of certain graphics operations when used with its DirectColor boards (see the text box "The QuickColor Option" on page 194). Other board vendors have also announced plans to introduce accelerators in the near future.

The boards draw screens slower than 8-bit boards do.

Since debuggers tend to be hardware-specific, I wasn't surprised that Apple's MacsBug 6.1 and ICOM Simulations' TMON 2.8.2 debuggers didn't work with these boards. But I found an easy solution: If the 24-bit color board is the second video board in your system, make sure that the Mac scans the standard video board first when booting. You can ensure this by placing the board in the slot next to the power supply on a Mac II. If you've got only the 24-bit video board, both companies offer solutions: Apple's MacsBug 6.1B1 is compatible with 32-Bit QuickDraw, and ICOM Simulations offers an Extended User Area (EUA) file that configures TMON to operate with a 32-bit display. Contact the companies' technical support to obtain copies.

Because of the debuggers' low-level interaction as they write to the Mac's screen, some boards didn't fare as well as others with the newer MacsBug and TMON EUA. The Spectrum/24 worked fine with both debuggers. The ColorBoard 224 worked with the new TMON EUA, but it stopped at start-up with MacsBug. For the DirectColor/24 board, MacsBug loads successfully, as does TMON, *if* the screen mode is 8 bits or less. But once you're in the debugger, the best you can do is engineer a "soft landing" for the system by making the Mac reboot, because you often can't resume execution at the interrupt point.

Tough Choices

These three boards offer similar features and excellent results, so choosing one over the others is tough. However, your decision can be guided by the type of work you want the board to perform. If you're doing color desktop publishing or CAD/CAM, go with the DirectColor/24 and Radius's two-page display. For budget-conscious software development work, use the Spectrum/24—it handles both debuggers and comes in at the relatively low cost of $3999.

If you do professional artwork or graphics design where you need to zoom in for detail frequently, that's the ColorBoard 224's strength. Or you might want to consider a stripped-down version of the NuVista (see the following section) as a video board in addition to using its graphics coprocessing and image-capture capabilities.

Scene Stealing

In the video-graphics board category, I looked at Data Translation's ColorCapture board and Truevision's NuVista 4M (see table 2 for a summary of features). The ColorCapture board gets you into the

continued

	Spectrum/24	ColorBoard 224	DirectColor/24
Company	SuperMac Technology 485 Potrero Ave. Sunnyvale, CA 94086 (408) 245-2202	RasterOps Corp. 2500 Walsh Ave. Santa Clara, CA 95051 (408) 562-4200	Radius, Inc. 1710 Fortune Dr. San Jose, CA 95131 (408) 434-1010
Price	Spectrum/24: $3999 19-inch Tritron display: $4200	ColorBoard 224: $5195 19-inch Tritron display: $4195	DirectColor/24: $4995 19-inch Color Display (includes stand): $4295 QuickColor Accelerator: $795
	Inquiry 856.	**Inquiry 857.**	**Inquiry 858.**

Note: For all products, required hardware is a Mac II-family computer with 2 megabytes of RAM running System 6.0.3/Finder 6.1 and 32-Bit QuickDraw.

image-capture game quickly with its plug-and-play setup. You simply install the board and software and attach the video cable to the board's video port, and you're set. The software consists of 32-Bit QuickDraw, a diagnostic application that checks the board, and a ColorCapture application.

I used a VCR and some tape recordings of TV programs as my video source. When you launch the ColorCapture application, a `Focus on MAC Display` menu selection presents a small 320- by 240-pixel window with 32 shades of gray on the Mac's monitor. This window shows a miniature of the video image, which is updated approximately two to three times a second. The window's limited resolution and the display's slow refresh rate correlate to the overhead required to capture and present an image on the Mac's screen.

In this mode, you can click on the mouse to capture a scene, although there

ColorCapture	NuVista 4M
Data Translation 100 Locke Dr. Marlborough, MA 01752 (508) 481-3700	Truevision, Inc. 7340 Shadeland Station Indianapolis, IN 46256 (800) 858-8783
ColorCapture (NTSC and PAL): $2995 Video I/O cable: $125 PhotoMac 1.1 software: $795	NuVista 4M: $6495 NuVista 2M: $4495 NuVista 1M: $2995 VIDI/O Box (NTSC): $995 VIDI/O Box (PAL): $1995 RGB cables: $50 RGB cables with alpha channel: $60 NuVista 34010 toolkit: $1500 (NuVista 2M can be upgraded with video RAM to NuVista 4M)
Inquiry 859.	**Inquiry 860.**

can be a slight delay between the time you trigger the capture and when the image is actually digitized. To catch the exact scene you want, watch the video on a TV set or an external monitor and seize the scene with the Grab Image selection from the keyboard.

You can zoom in on an image to examine details, but that's about it. The board lets you save the image as a TIFF or IMAGE (Data Translation's own format) file. The company plans a future version of ColorCapture to allow you to crop and change the bit depth of images and save to more file formats. Data Translation's PhotoMac application, normally used for color image manipulation, offers a capture function that works with ColorCapture. From within PhotoMac, you can grab an image and then work on it with a number of retouching tools or make a color correction.

PhotoMac 1.1 takes about 10 seconds to open a window with the captured image. As with the `Focus on MAC Display` capture, there's an image lag between the time you initiate a capture and the time an image actually shows up on the Mac's screen. However, PhotoMac gives you the opportunity to work on the image, save it in additional file formats, and print it.

Swiss Army Knife

Although it serves as a frame grabber, Truevision's NuVista 4M video-graphics board is hard to categorize. That's because the NuVista does practically everything. First, it serves duty as a typical Mac video board, handling modes from black-and-white to 32 bits per pixel. Second, it can drive a variety of monitors: interlaced, noninterlaced, NTSC, and PAL. Next, when running

continued

The QuickColor Option

Radius claims that its $795 QuickColor Accelerator, an optional NuBus board that works in tandem with Radius video boards, boosts the performance of certain 32-Bit QuickDraw operations by 600 percent. Although our tests showed much more modest results overall, the need for an accelerator is apparent to anyone familiar with 32-Bit QuickDraw.

QuickDraw normally takes an application's graphics call and reduces it to low-level graphics primitives. For example, drawing a filled square invokes a procedure that draws a rectangle, then a bit-transfer procedure that fills it. These primitives are called "bottleneck routines" because their efficiency affects how fast objects are drawn. You access them via pointers; this makes it easy to swap out a routine's code by simply changing the pointer's address.

The Mac's CPU must execute large amounts of QuickDraw code and move volumes of data (particularly if an image is 24 bits deep) when drawing to the Mac's screen. The problem is particularly acute for large displays, like the Radius Color Display with over a million pixels.

A major problem involves the data transfer rate from the Mac's main memory to the video board's frame buffer on the NuBus. For the Mac's CPU to write to the NuBus, it must first synchronize this I/O operation with NuBus operations, which are handled by a chunk of complex hardware logic termed the NuBus state machine. Additional clock cycles are required to drive this state machine. Radius has calculated that the transfer rate from main memory to the frame buffer on a NuBus board is 3.8 megabytes per second.

The Solution

The QuickColor board improves data transfer rates by moving the bulk of the drawing operations onto the NuBus. This is done by patching some (but not all) of the QuickDraw bottleneck procedures and using a 5-million-instruction-per-second Acorn VL86C010 RISC processor on the QuickColor board. When the Mac boots, an INIT loads multitasking code into the RISC processor's static RAM and also patches the QuickDraw bottleneck procedures. When an application performs drawing operations, the patched routines write RISC instructions to the QuickColor board instead of writing pixel data.

The RISC processor executes these instructions and manipulates the video board's frame buffer. With drawing operations occurring on the NuBus, the overhead of the NuBus state machine is eliminated or reduced. Since all Radius video boards can handle NuBus block transfers, the QuickColor board can act as a NuBus master and blasts data to the video board's frame buffer at rates of 27 megabytes per second.

Certain drawing operations don't benefit from this scheme. For example, it can't handle off-screen pixel maps, the color images that reside and are manipulated in the Mac's main memory and then transferred to the board's frame buffer. However, once this data is in the frame buffer, the QuickColor board can perform other operations, such as scrolling the image in a window.

Test Results

I tested the QuickColor on a Mac IIcx equipped with a DirectColor/24 board and a Color Display. I first constructed a two-page PageMaker 3.0 document loaded with 24-bit scanned images and text. I timed my scrolling about the document with the QuickColor Accelerator enabled, and then with it disabled. The results appear in table A. Results vary because portions of the images had to be fetched from main memory as the document scrolled across the screen. The overall improvement in screen drawing averaged 33 percent.

Text handling showed a noticeable improvement as well: In the 24-bit mode, I scrolled several times faster through a text-only MindWrite 2.1 document. This outpaced scrolling the same document, unaccelerated, in the 8-bit mode, which took 55 seconds. The boost for handling text is significant since 32-Bit QuickDraw performs poorly in this area. These tests indicate that the QuickColor Accelerator's performance boost may be useful for color prepress work.

Table A: *The following times (in seconds) gauge video activities with and without the QuickColor Accelerator.*

ACCELERATOR TESTS

	Unaccelerated	Accelerated
Scroll two-page PageMaker document, 24-bit mode		
Scroll left	44	40
Scroll right	41	28
Scroll down	37	22
Scroll up	24	11
Scroll down 10K-byte MindWrite document, 24-bit mode		
Scroll left	180	48

32-bit pixel displays, it can use that spare byte as an alpha channel to overlay video with an image or text. Finally, it offers an on-board 50-MHz TMS34010 graphics coprocessor, which can generate graphics and animations.

Since the board's output is RS-170 RGB, both the Mac Desktop image and the coprocessor graphics can be displayed and recorded. However, for the board to handle any sort of composite video input or have its output saved to a VCR, you will need to have a video encoder/decoder unit to convert analog RGB video to composite video signals. Truevision provides an optional two-way encoder/decoder unit called the VIDI/O Box for this purpose.

Installation is a little bit more complicated for the NuVista board than for some of the others. Putting the board in the slot is easy enough, but then you have to install the proper video driver for the monitor that you'll be using. The NuVista SetUp application loads the appropriate driver from a NuVista Driver file

continued

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onto the board. These drivers support up to 1536 by 485 pixels (NTSC interlaced) or 756 by 485 pixels (NTSC noninterlaced). Be careful if you're using this one board for your Mac screen and you want to try loading a different driver (perhaps for a larger display). The driver may black out the screen, and relaunching the setup application to reinstall an alternative driver is awfully difficult.

For the test setup, I routed VCR output through a VIDI/O Box to the NuVista board. The NuVista alternately drove an AppleColor RGB monitor and an NEC MultiSync XL monitor. The displays were rock-steady except during image capture.

If you're using a noninterlaced monitor with the board, you won't be able to view live video on the screen while capturing an image. As with the ColorCapture, I most easily obtained images using the `Capture Image` menu command with the keyboard. Be aware that the display momentarily goes berserk during image capture as the board shifts to interlaced frequencies to capture the image.

You can save the image as a PICT (32, 16, or 8 bits deep) or 32-bit TGA file. This TGA format is identical to the TARGA file format used by Truevision boards on PCs, and it's useful for sharing images in a shop with different computers. The company provides Apple File Exchange translator files that can convert a PICT file to a TGA file and back.

By routing the Mac monitor's output back to the VIDI/O Box and then to the VCR, I taped scenes of the Mac Desktop. However, the 1-pixel-thick horizontal lines that are present on every Mac window flickered annoyingly. According to the NuVista manual, this happens because these lines are displayed only half the time on an interlaced display. You must carefully adjust the Desktop colors to reduce this shimmering effect.

Spectrum of Opportunities

Both boards did a good job of capturing NTSC video images. The images weren't as sharp as scanned images, but that's due to the limitations of the video signal, not the boards.

The NuVista board is more versatile than the ColorCapture in several areas, and the software seems more mature. But the NuVista requires the encoder/decoder for composite video. In this respect, the ColorCapture holds the advantage—you can set it up quickly and use it right away with your VCR or camcorder.

Professional artists had contended that computers wouldn't replace conventional materials until they worked with millions of colors. With these boards, the Mac achieves this goal. Artists now have the large pixels required to adequately represent subtle changes in hue. Scanned photos can be displayed realistically, which makes electronic retouching possible. Images can be imported and previewed in page-layout documents, opening up a new market in color desktop publishing.

What can you do with millions of colors? Plenty. Five off-the-shelf boards already capitalize on using that many colors, and these products are just the start. Best of all, this accessible technology isn't rocket science. So I leave image workers with a new question: "What are you waiting for?" ■

Tom Thompson is a BYTE senior technical editor at large. He can be reached on BIX as "tom_thompson."

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Power to the Programmer

Watcom's new C compiler unleashes the 80386

Fred Hommel

When Novell went looking for a 32-bit compiler for use with the NetWare 386 developer's kit, the company selected Watcom's. That compiler, packaged for use with DOS extenders from Phar Lap and Eclipse Computer Solutions (formerly A.I. Architects), is now available directly from Watcom.

In addition to tapping the full power of the 80386, Watcom C 386 provides library and source compatibility with the de facto Microsoft standard. The prospect of being able to port programs from DOS, as well as Unix, was very exciting. Of course, any programs you port or write will run only on 80386 or 80386SX computers, but if speed and a large address space are what you need, this system can deliver.

All this power isn't cheap. The compiler itself will set you back \$895, but that's not all you need. To run the programs you compile, you'll need a DOS extender—a program that kicks the 80386 into its native protected mode while presenting a DOS-like interface to programs. Phar Lap's 386|ASM/LINK costs \$495; the debugger, 386|DEBUG, costs an additional \$195. Eclipse Computer Solutions' OS/386 sells for \$495 and includes a debugger.

At the Starting Gate

To test Watcom C 386, I used the latest version of OS/386. This version is less well known than the Phar Lap DOS extender, but it's a powerful product. The operating system is supplied in the form of a TSR program, which is removable should you need the space for other tasks. One intriguing feature is a driver that you can use to run well-behaved DOS programs in virtual 8086 mode. Such programs can then use the device space above 640K bytes and so effectively address 960K bytes of RAM. The GIVEAMEG utility tweaks the header of an otherwise unmodified DOS program to make this possible.

The protected-mode loader, UP (the equivalent of Phar Lap's RUN386), loads and executes such programs, as well as full 32-bit applications that run in protected mode. After you've developed a 32-bit application, you'll want to distribute it. Eclipse Computer Solutions offers its BIND utility, which bundles a DOS extender kernel with your application, on quite reasonable terms. The manual that comes with OS/386 is superb and covers just about everything you need to know.

I used OS/386 because I'm more familiar with it than with the Phar Lap tools. Although Watcom supports both DOS extenders, Watcom C 386 is clearly Phar Lap-oriented, which made getting started a bit tricky. First, because the linker provided with OS/386 doesn't support the Phar Lap object-module format—it's from Lahey, the FORTRAN company—you have to run the Watcom libraries through the Lahey library manager in order to get them into the right format.

Then, because of differences between the two DOS extenders, you have to replace the start-up modules. Since the library manager insists on appending .OBJ to any filename you give it, you must rename the Watcom start-up files—CSTART3R.LBJ and CSTART3S.LBJ—using .OBJ extensions, lest the library manager tells you that it can't find the file CSTART3R.LBJ.OBJ. (I figured this out from a README file in the OS/386 distribution disk; Watcom should mention it in its own documentation.) Finally, the Watcom compile-and-link tool, WCL386, generates a command file for Phar Lap's linker, so if you're using OS/386, you've got to roll your own compile-and-link batch file. Once I sorted these matters out, I was off and running.

The Watcom C 386 toolkit includes a stand-alone preprocessor (WCPP386), the compiler's front end (WCC386), the compile/link tool (WCL386, which currently supports just the Phar Lap linker), two code generators (386WCG and 386WCGL), a make utility (WMAKE), a patch utility for upgrading the compiler and tools (WPATCH), an object file disassembler (WDISASM), and a text editor (WEDITC). The stand-alone preprocessor is a nice touch; macro expansions can get tricky, and it's a good idea to be able to review the code that's actually fed to the compiler.

The code generators differ only in the memory models they embody: 386WCG is a medium model program (big code, small data), and 386WCGL is a large model program (big code, big data). You'd use 386WCG to coexist with, for example, a resident network shell, and switch to 386WCGL should the medium-model program's optimizer run out of memory.

The documentation includes a user's guide, a C language reference, and a library reference. The library reference is in much the same format as the one that comes with Microsoft C 5.1, except it has a good table of contents with all the functions listed alphabetically. Each function's description has six parts. The Synopsis section tells you what include file you should use, and it gives a function prototype. The Description, Returns, See Also, and Example sections do what their names suggest. The Classification section identifies a function as one of ANSI, POSIX, DOS, or WATCOM.

continued

Watcom C 386

Company
Watcom
415 Phillip St.
Waterloo, Ontario
Canada N2L 3X2
(800) 265-4555

Hardware Needed
An 80386 or 80386SX computer with 640K bytes of RAM

Software Needed
Phar Lap's 386|ASM/LINK or Eclipse Computer Solutions' OS/386

Documentation
User's manual; library reference; language reference; text editor manual

Price
$895

Inquiry 881.

The compiler supports five different memory models: flat (the default), small, medium, compact, and large. However, library support is only provided for two memory models, small and flat. You can use only the small model under OS/386 due to the constraints of the linker provided. Of course, "small" in the 32-bit world means 4 gigabytes, so there's no need to feel cheated. In the flat model, there are, effectively, no segments. In the small model, code and data are referenced by means of near (32-bit) pointers. The far keyword will permit use of far (48-bit) pointers. So, for example, you can access video RAM from within a C routine.

The compiler has two schemes for passing arguments to subroutines: in registers (the default) or on the stack. Each scheme has its own version of the runtime library, and if you switch from the register scheme to the stack scheme (by means of a command-line switch), you have to be sure to also use the stack-oriented library. Watcom also provides an unusual and powerful pragma syntax that you use to gain complete control over which registers can receive arguments and how they're passed.

A word of caution. Routines that take variable numbers of arguments must be written using the macros defined in the ANSI specification, or they won't work properly. Not all Unix programs do that, so beware.

Off to the Races

To test both the Unix and MS-DOS/Microsoft compatibility of the compiler, I ported a public-domain spreadsheet, sc, to the 32-bit DOS environment. The spreadsheet itself is a Unix program; the PCCURSES package (also public domain code) that I used to implement sc's screen and keyboard I/O makes heavy use of DOS and BIOS function calls.

The spreadsheet ported with little difficulty. The only major snag had to do with macro substitution. As it turned out, it wasn't Watcom's fault. The compiler performed per the ANSI draft specification. The problem was that the Unix preprocessor used to develop sc had been a bit looser in its enforcement of the rules. In the end, Watcom's technical-support department came up with a workaround, and I was on my way.

The next task was to get PCCURSES running. It's written such that all the actual screen I/O is done through one module; you even get a choice of an assembly or C version. I chose the C version, and in general, things went smoothly. I did, however, have to account for a minor difference between the Microsoft C and Watcom C 386 libraries. Both libraries use a union called REGS in conjunction with software interrupts to the BIOS or to DOS. Watcom alters that union to handle the register architecture of the 80386 and replaces the standard `int86` and `int86x` function calls with `int386` and `int386x`. So I had to rename the `int86` and `int86x` calls and make sure that REGS was set up properly. That didn't take long, though, because only a handful of function calls were involved.

While tracking down the structure changes, I ran into the problem of trying to debug a program written with the compiler. The problem is that there is no source-level debugger. Watcom told me that it is working on both a debugger and a linker. I was able to get by using the CP debugger provided with OS/386.

Once the program was working, its power was quickly evident. I filled a spreadsheet with 3 megabytes of data (from cell a0 to cz198) and was able to recalculate it in seconds.

I also ran a set of benchmarks using Watcom C 386 and MetaWare's High C 386 (under OS/386) and Microsoft C (under DOS and OS/2). The tests were run on a 20-MHz Compaq Portable 386 with 10 megabytes of 32-bit RAM. I tested the Watcom compiler using both

continued

Table 1: *The Watcom and MetaWare compilers, under OS/386, outperform Microsoft C 5.1 under both DOS and OS/2. All times are in seconds.*

COMPILER BENCHMARK RESULTS

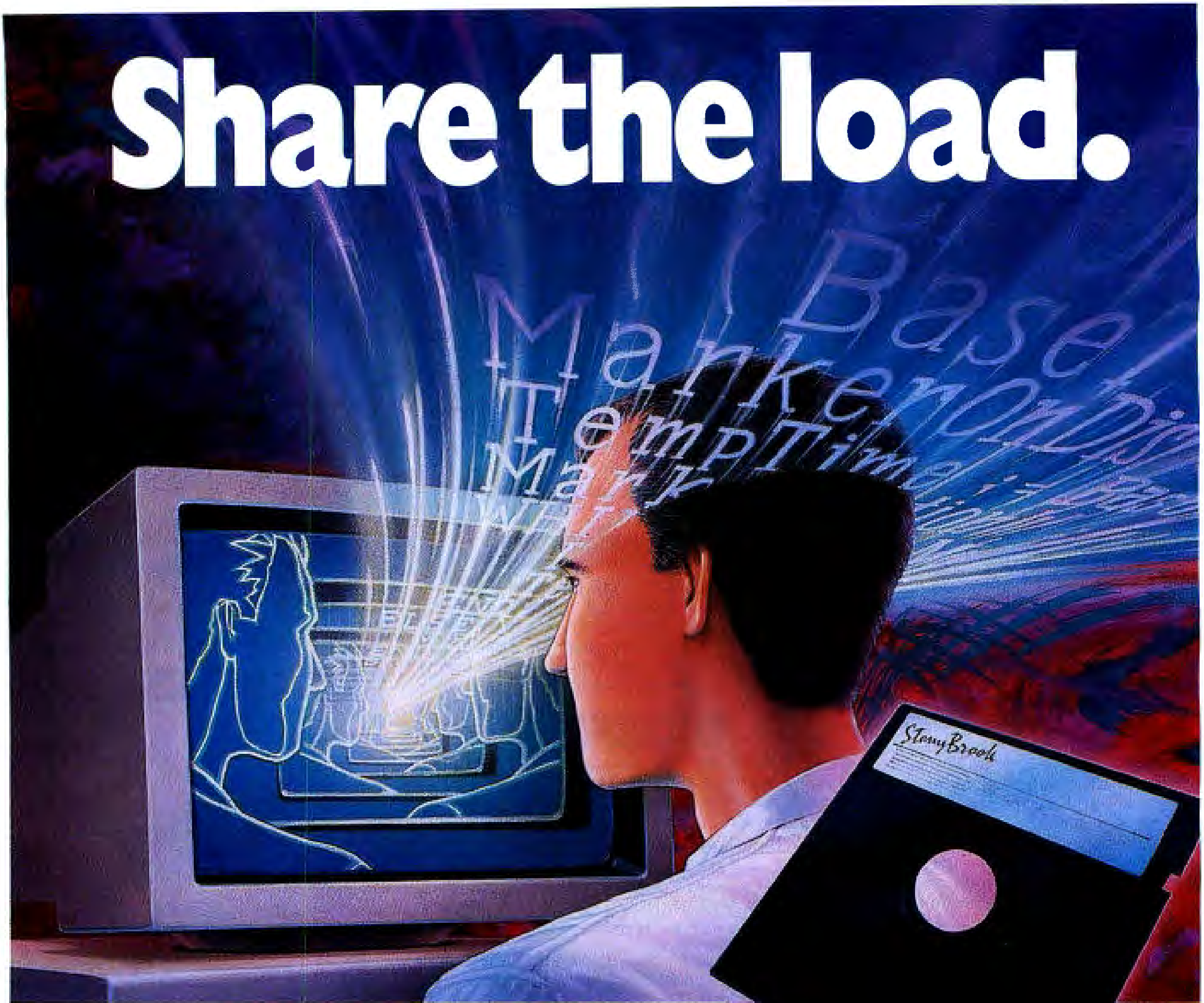
	Watcom C 386 7.0			MetaWare High C 386 1.4		Microsoft C 5.1	
Benchmark	**Iterations**	**Register**	**Stack**	**Aligned**	**Unaligned**	**DOS**	**OS/2**
Fibonacci	100	34.28	44.38	41.64	40.92	42.18	42.72
Sieve	1000	34.60	34.61	45.70	47.73	46.58	47.13
QuickSort	1000	62.18	63.38	60.48	61.02	111.91	120.22
Eight Queens	1000	40.09	45.48	42.73	41.96	59.15	59.90
Dhrystones/second		7334	6503	7741	7714	606	5950

the register- and stack-oriented argument-passing schemes. Since the MetaWare compiler can align routines and labels on quadword boundaries—an optimization that the Watcom compiler currently doesn't support—I compiled under MetaWare both with and without that option. As table 1 shows, the Watcom and MetaWare compilers (both known for quality optimization) turned in comparable performances. Both significantly outperformed Microsoft C 5.1 under DOS and OS/2, especially on the Dhrystone and QuickSort tests.

I like this compiler. The library support is superb; Watcom even includes the POSIX directory functions. I appreciated the inclusion of a disassembler. The use of registers for passing arguments is clearly a powerful optimization. There are a few wrinkles. The lack of a debugger is the most obvious one. Another is that the only foreign language supported is assembly. If you want to mix FORTRAN and C in a 32-bit environment, you'll have to find another solution (although Watcom says that it's working on a FORTRAN compiler). But these are minor and correctable problems. It's clear that Novell chose wisely; this product is a winner. ■

Fred Hommel is an independent software consultant specializing in OS/2 conversions. You can reach him on BIX as "fhommel."

Circle 202 on Reader Service Card (DEALERS: 203)



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High-Fashion Unix on a PC

The HP way to make a high-quality color X Window display server out of an IBM AT

Ben Smith

Hewlett-Packard has an excellent budget saver for departments needing quality color X Window user workstations: the Accelerated X Window Display Server (AXDS/PC) for IBM ATs. A quality color X Window workstation usually costs more than $15,000. For roughly $5000, though, you can upgrade a LAN-ready, AT-type computer (such as the HP Vectra) to a 1024- by 768-pixel color display server.

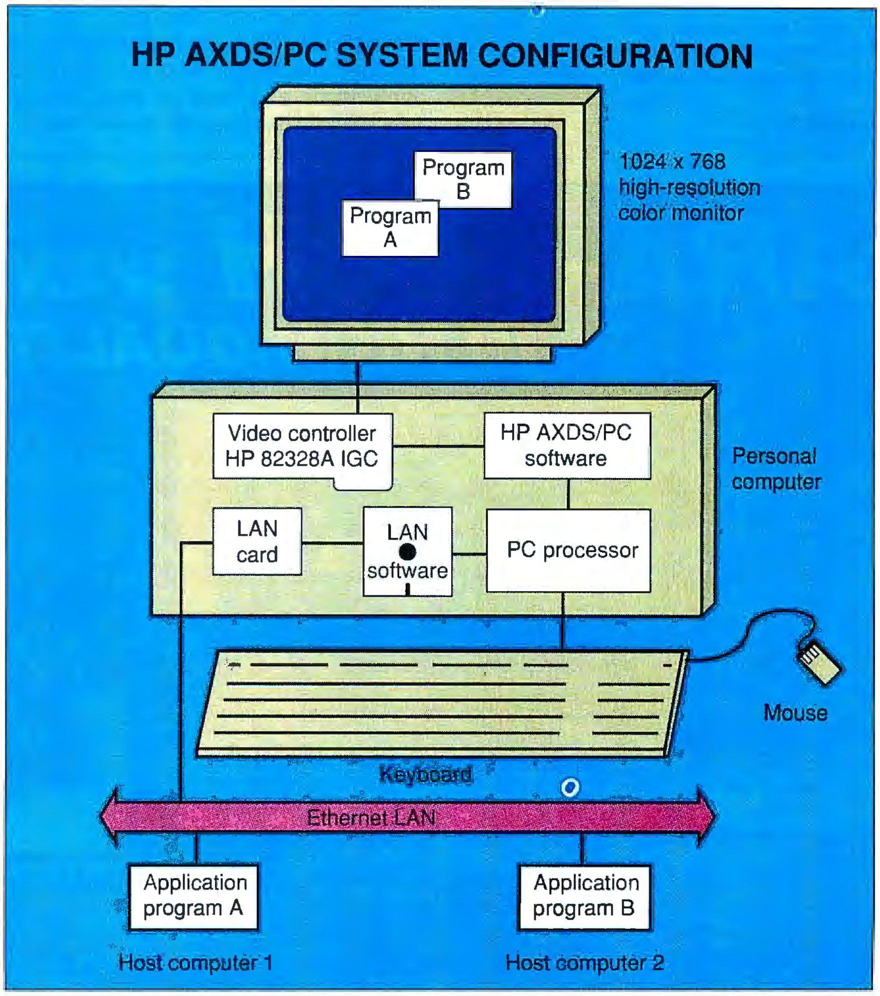
Clients and Servers

The X Window System from MIT is the de facto standard graphics window system for Unix. It is designed for environments where the user terminal connects by a network to several computers running the applications that use windows and graphics for the user interface. The X Window System works equally well on systems where application programs are on the user's local computer (see "The X Window System," January BYTE).

In the terminology of the X Window System, the application programs are *client processes*, and the processes that are specific to the keyboard, mouse, and display are *server processes*. The X Window server processes are responsible for interpretation of requests from client processes for activity on the server device. The client processes do not contain any information about the specifics of the physical location or characteristics of the server.

For example, if a client process wants to be notified of pointer activity within a window associated with that process, it sends a request (`MotionNotify`) to the server. The server is responsible for managing the physical devices (in this case, the mouse and the screen), moving the display pointer, detecting when the pointer is in the associated window, and keeping track of where in the window the pointer is located, as well as where the window is located in the root window (the full screen) and a number of other data. The server passes the information

continued



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Software Needed
MS-DOS or PC-DOS 3.1 or higher

Documentation
Installation guide

Price
HP AXDS/PC software only: $500
HP 82328A Intelligent Graphics Controller: $1480
HP 82329A EGA Emulation Module for 82328A: $415
HP D1188A 16-inch MultiSync Color Graphics Monitor: $2795

Inquiry 882.

back to the client when an appropriate event occurs. In addition, the server is responsible for handling character fonts and drawing functions and applying them to the specifics of the server hardware.

A machine that is capable of handling both client and server processes fits most of the requirements of a Unix workstation (see "Unix Workstations Connect" on page 123).

Workstation or Display Server

To qualify as a Unix graphics workstation, the AT would have to run Unix as its operating system and be capable of doing some of the client processing. However, the AXDS/PC software is installed under MS-DOS. In fact, even while the network and X Window server are running, you can escape to DOS. Therefore this package does not turn an AT into a complete workstation; it requires a separate Unix machine for running all the client processes (see the figure). But the niche that it fills is an important one: a machine for people who use MS-DOS applications and want to avoid having two separate machines to do their work.

High Speed and High Quality

The design concept is for high speed and high-quality graphics processing using the base platform of the AT. The weakness of the AT design is that the graphics processing speed of the Intel 80x86 processor (especially under DOS) is not sufficient to handle the heavy loads of multiple high-resolution windows. The HP solution is the HP 82328A Intelligent Graphics Controller High-Resolution Graphics Card. By programming the card to perform the X Window operations, the only services that AXDS/PC requires from the DOS machine are program storage and loading and font storage and loading.

To do this, the graphics card has to be fast and smart. The key is the Texas Instruments TMS34010 Graphics System Processor (GSP) chip (see the December 1986 BYTE). This GSP chip runs at 40 MHz providing short-term performance of nearly 5 million instructions per second (MIPS). It can address up to 4 gigabytes of memory. It has an on-board instruction cache for 128 16-bit instructions, and it has 31 32-bit registers.

continued

Circle 138 on Reader Service Card

The HP 82328A Intelligent Graphics Controller can produce 16 colors (out of a palette of 4096), with a resolution of 1024 by 768 pixels. You can expand the DRAM used to store the X Window Server programs for the TMS34010 and Window data structures to 2 megabytes, providing enough space for dozens of concurrent windows. The video information is stored in separate RAM. The board will also emulate IBM's EGA for DOS applications.

The Brains Behind the Brawn

All this graphics power is of no use without a good program to use it. The control is provided by the HP AXDS/PC software, an implementation of X Window System 11 release 3 written for the TMS34010. I evaluated the HP AXDS/PC on an HP Vectra ES/12—a 12-MHz 80286-based system. Every function, including font handling, color, and shading, appeared to be the same on the HP AXDS/PC system as on the $40,000 Unix engineering workstation handling the client processes. The only noticeable degradation was in drop-down menus, with which momentary lags made the pointer tracking and selection response time uncomfortable to use.

The compatibility between the two systems is complete to the finest detail. The performance was more than adequate for all standard applications. HP claims that the performance is equivalent to a 2-MIPS workstation with 2 megabytes of RAM. Graphics drawing and typesetting applications ran faster than on most PCs, and any professional would be happy with the quality and resolution.

Usability and Price

This is a very usable implementation of the X Window Server design. The cost of the software and graphics controller card is reasonable, especially considering that Hewlett-Packard is noted for reliability. The most expensive element of your upgrade will be buying an HP color monitor, ranging in price from $2795 up to $6850. I see little point paying any more for a tube that has image-resolution specifications far above those of the display card. The system I tested used the "low-end" D1188A 16-inch MultiSync Color Graphics Monitor. It was crisp, bright, and sufficient for any color or form generated by the display board.

HP recently announced the HP Intelligent Graphics Controller 10. This board can reduce the expense by an additional $2000, because it can accept a VGA graphics card and display in place of the more expensive HP MultiSync Color Graphics monitor. In addition, this new board uses a 50-MHz 34010.

It's reasonable to expect better performance on menus with future releases of X Window, Motif GUI, and the Texas Instruments GSP chips. It's also reasonable to expect greater demands on X Window servers with the development of more software that uses them. The GUI (graphical user interface) is one area where the software design is pushing the hardware design.

In the meantime, HP AXDS/PC software for the TMS34010 is an economical way for the occasional workstation user to get the quality and performance of a truly fine color graphics workstation on an MS-DOS computer. ■

Ben Smith is a BYTE technical editor and resident Unix guru. You can reach him on BIX as "bensmith."

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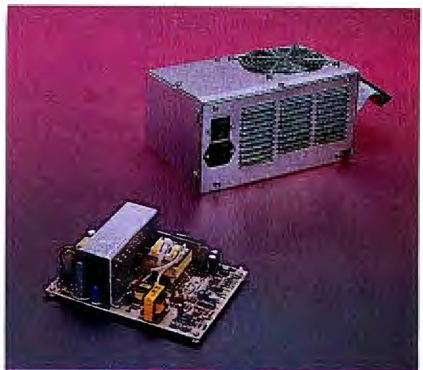

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Clipper Applications Get SQL

Planet Software's library of functions includes linking Clipper applications to SQLBase

Marc Schnapp

One reason for developers' intense loyalty to Clipper, the dBASE-compatible compiler, is its thriving aftermarket support. The Library from Planet Software is the latest and perhaps the most heavily promoted third-party library offering for Clipper to date. Both Gupta Technologies (makers of SQLBase) and Nantucket (Clipper's maker) aggressively positioned The Library as a SQL application programmer interface (API) to Clipper. Developers not seeking SQL support might write off Planet's product, but The Library merits a closer look—SQL support comprises less than one-third of the product's 360 functions.

Array of Functions

A sampling of array-handling functions demonstrates the strengths of The Library. The functions range from the obscure to the compelling. Among the selections are `l_argen()`, `l_argtn()`, `l_argles()`, and `l_arltn()`. Respectively, these functions compute how many numeric array elements are greater than or equal to, greater than, less than or equal to, or less than a given numeric value. All are quite useful as they are, but Planet could have also included a more generic function taking a user-supplied comparison operator as a parameter. Such a function would facilitate interactive queries. As implemented, the developer must place each of the function calls in a CASE block.

Another useful array function, `l_arcount()`, counts occurrences of a designated data type within an array of a programmer-specified value; this could prove useful in building crosstabs.

The Library's best functions lend themselves to statistical analysis, computing mean, median, and mode values. The Library provides trigonometric functions (e.g., cosine, inverse cosine, arcsine, tangent, and arctangent) and financial formulas (e.g., future value, present value, loan amortization, and payments). Statistical functions provide the coefficient of variance, standard deviation, and variance. Other quantitative functions provide hexadecimal-to-decimal (and decimal-to-binary) conversions, prime-number checking, and a routine to bypass divide-by-zero errors.

Planet's product covers a lot of territory in its conversion functions. A British-developed product, The Library has a full complement of imperial-to-metric measure transformations. Among them are pounds to kilograms, inches to centimeters, Fahrenheit to Celsius, gallons to liters, and acres to hectares. For applications requiring geometric calculations, The Library can determine volumes of spheres (or their radii), cylinders and cones, and areas for parallelograms.

Date and time functions perform diverse tasks: calculating differences in dates in weekdays, weeks, months, or years (dBASE date math can calculate days). Other functions validate dates and string equivalents. The Library provides functions for internally calculating time intervals, using strings to nicely make up for that dBASE language deficiency.

Planet provides source code in assembly, Clipper, and C (for all functions but the SQLBase API). The source code gives you the ability to modify and extend the library. It is not only well commented but also compact, with files ranging from 2K bytes to 5K bytes each.

Clipper-coded functions do occasionally make nested references to other functions, making code modification and maintenance a bit more involved. The Library also includes nifty functions to simulate two-dimensional arrays (Clipper 5.0 adds one-dimensional arrays that permit array elements to point to other arrays).

A Few Weaknesses

Many of The Library's functional categories are superficial and are far better handled by the competition. These gaps are evident in the functions for the keyboard, printer, graphics, mouse, disk, file, and memory.

Disk functions include changing, validating, making, and removing directories; obtaining time and date stamps; and checking hard disk drives. What is missing are functions determining total space and storage available on a given hard disk drive. The Library can determine extended and expanded memory configurations, but it makes use of neither (Gupta's engine and router, however, do require extended memory). The manual incorrectly asserts that Clipper uses extended memory for index buffering (Clipper uses up to 1 megabyte of expanded memory for that purpose).

The Library also offers graphics primitives for plotting business charts. Developers can switch display modes, save screens to disk, and examine screen file contents. Routines for fundamental mouse functions are provided—they monitor button presses and movement intervals. However, most Clipper applications are character-based. To use the mouse for menu selections, developers must use a separate TSR program that converts mouse movements into cursor key presses. This does not qualify as robust support for mainline Clipper applications development. And because Nantucket does not provide graphics mode support, these functions provide nothing

continued

more than a tentative starting point—developers will have to build on the 25 mouse functions provided. If your goal is to customize Clipper applications for VGA or EGA support (particularly exploiting The Library's graphics functions), these fill the bill.

On-Line Help

Also included is a Norton Guides data file (Nantucket sells the Norton Guides along with a data file for the Summer 1987 version) and a full disk of sample files.

The Norton Guides memory-resident help system is a modest advance in applications development. Programmers can quickly pop up syntax skeletons and full-text examples while coding. Providing simple cross-referencing, the Norton engine includes a "see also" lookup facility. You can also configure the help engine to automatically look up functions, using the same approach as memory-resident spelling checkers and thesauri. Many developers banish print-reference manuals to the furthest reaches of their offices as a result.

The inclusion of an on-line help system makes it possible for developers to perform field modifications and upgrades without toting along unwieldy documentation. All products of this kind should include TSR program help, and several other library vendors already do so. I wish that Planet's library help system permitted full categorization. However, once you know which function you wish to use, the Norton data file is an excellent way to confirm function syntax. I also wish that the 28-page extensive error system for SQLBase in the reference guide was in the Norton help file.

A sizable loose-leaf manual with more than 500 pages also details the operations of each function. A quick reference section summarizes the calling conventions for each function. Broken into subsections by functional category, each section includes a category list.

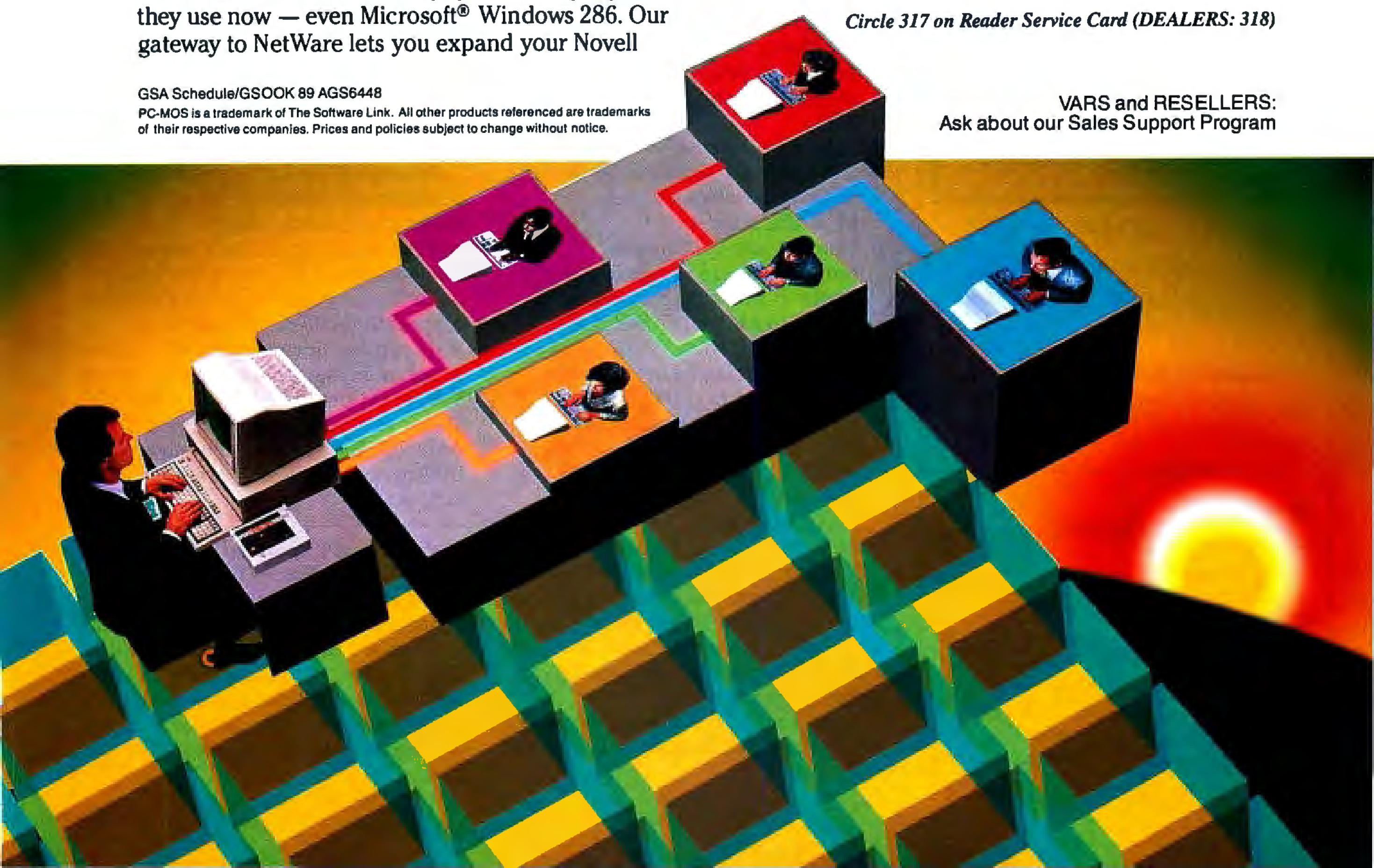
With a library this extensive, developers are likely to scan the function lists as they program. Additional tabs in the documentation, marking off the function categories, would help on that score. The memory-resident help software could also facilitate searches, but the Norton Guides system lacks a means of categorizing its contents. Planet did not assign category-wide prefixes to its function names, so programmers won't be able to track them down alphabetically. (All SQLBase functions are preceded by "S_"; all the others are prefixed with "L_.")

The SQL Story

The transition to SQL is not absolutely seamless. You'll need to work with either the single-user version of the Gupta SQLBase engine or the multiuser router. You will need to dedicate at least 385K bytes of extended RAM to SQLBase for these purposes. Unless Gupta also makes EMS support available, SQLBase support for Clipper applications will rule out the use of CPUs predating the 80286.

Proficient Clipper and dBASE language programmers will also have to negotiate the conceptual differences between their accustomed record-by-record logic and the set model used by SQL. Planet's SQL API supports cursors, stored contexts that the host application manipulates.

continued



The Library

Company
Planet Software, Inc.
1040 Marsh Rd., Suite 200
Menlo Park, CA 94025
(415) 688-1088

Hardware Needed
IBM PC or compatible

Software Needed
MS-DOS 2.0 or higher (3.1 or higher for network support) and Clipper (Summer 1987 version)

Documentation
Reference manual; data file for memory-resident Norton Guides help system

Price
$249

Inquiry 886.

The sequence works something like this:

1. Confirm that SQLBase is installed (S_ISENGINE( )).
2. Log onto the database system (S_CONNECT( )).
3. Assign a cursor to your query, pass the query to SQLBase, and compile it (S_COMPILE( )). Query strings cannot exceed 128 characters. While this might be a limitation, subqueries can always be issued against the prior result table.
4. Allocate a data buffer to hold the result table (S_SETBUFER( )).
5. Execute the compiled query (S_EXECUTE( )).
6. Here's where the Clipper programmer can engage in row-by-row processing, performing fetches in a loop (DO WHILE NOT S_EOF( )).
7. Within the loop, fetch the next available row (S_FETCHNXT( )).
8. Optionally assign the contents of each field individually to variables (S_READ( )).
9. Disconnect from the database (S_DCONNECT( )).

The Library supports embedded variables (bind variables) within queries, making run-time substitutions possible. Transaction processing with COMMIT and ROLLBACK is also within the reach of the Clipper developer.

The manual offers straightforward explanations of the fundamentals. A model three-page edit routine and a three-page append program are also offered for guidance. However, the manual is not a SQL tutorial. Clipper developers lacking SQL experience should tackle formal reference materials such as C. J. Date's *A Guide to the SQL Standard* (Addison-Wesley, 1987).

The Answer?

The Library for Clipper is a massive but spotty addition to the stockpile of Clipper tools. It provides strong support for quantitative functions and a well-documented Clipper API to the Gupta SQLBase database engine. It is not, however, the only library a Clipper developer should ever want to acquire.

The Library from Planet contributes substantially in its quantitative functions and SQL support. Savvy programmers can also adapt the source code as one measure to fill in The Library's gaps. Developers with particular needs might select specialized libraries to supplement Planet's product. For example, a full range of communications functions is found in the SilverComm library from SilverWare; also, NetLib from Communication Horizons extends network support beyond the basic locking included with Clipper. While the Planet library offers rudimentary business graphics, Pinnacle Publishers' dGE offers just about everything a developer might need (including an interactive test shell with a code generator). And FUNCky from dLesko Associates furnishes support where The Library is weak: disk and file I/O, character-mode mouse support, and keyboard control.

Pricing for The Library is in scale with competitive offerings. And because Planet has chosen to observe Nantucket's extend system, there is little likelihood of version shock as Clipper 5.0 emerges.

The Library should prove invaluable to corporate MIS departments seeking SQL applications support. While Nantucket promises future links with the Sybase/Microsoft/Ashton-Tate SQL Server and IBM's OS/2 Extended Edition, SQLBase is available now on all DOS networks. The Library exploits that fact. ■

Marc Schnapp founded the New York Metro Clipper User Group and is the president of its parent organization, the Professional Association of Database Developers. He operates Micro Business Services, Inc., a training, technical writing, and applications development company in Queens, New York. He can be reached on BIX c/o "editors."

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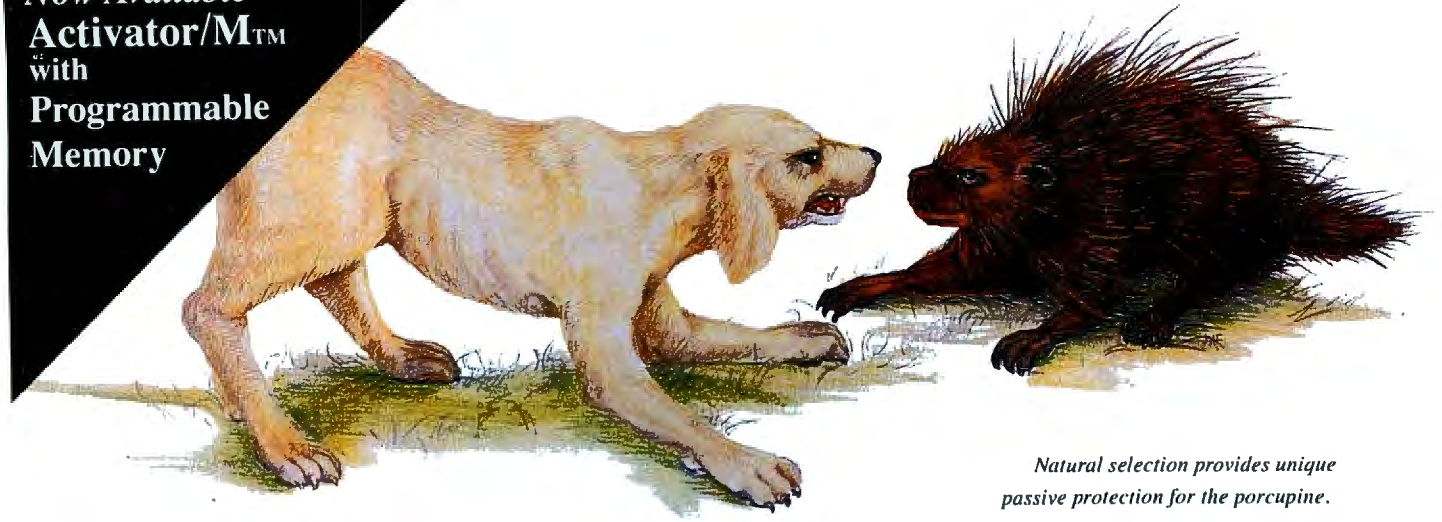

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Move Over, PageMaker

Publish It for the Mac brings new features to desktop publishing on the Mac

Diana Gabaldon

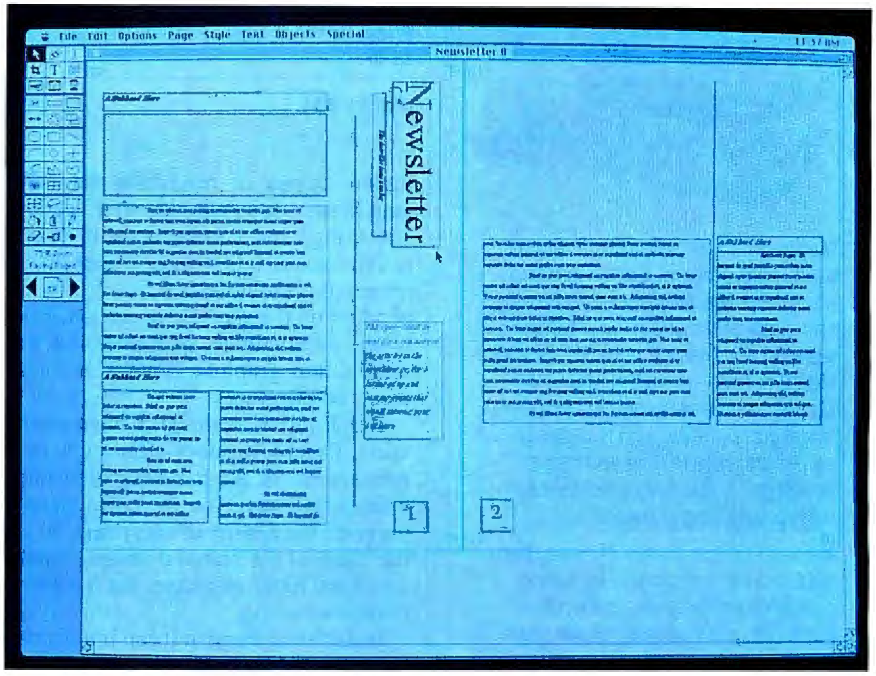
An increasing number of desktop publishing packages are entering the Macintosh market, from the fairly simple Quark XPress to the complex PageMaker, and there's always room for one that adds more features, like TimeWorks' Publish It.

While the MS-DOS version of Publish It is no great competition for either Ventura Publisher or PageMaker on the PC, it's a different story for the Mac version. In fact, Publish It for the Mac just may give PageMaker a run for the money.

New Features

Publish It contains most features found in other desktop publishing packages, as well as a few you won't find anywhere else (including Publish It for the PC). Text can come from virtually anywhere. Publish It will import text from WordPerfect, Microsoft Word, Microsoft Works, MacWrite, Write Now, or any other word processor that produces an ASCII text file. If none of these is handy, you can use the built-in word processor. There's also a 240,000-word thesaurus and a 160,000-word spelling checker.

The layout system lets you wrap text *inside* as well as around objects and use "V" (pyramid and slanted) margin formats, which most other desktop publishing packages don't offer. Text can flow through successive or staggered pages.



Publish It for the Mac gives you new text formats such as vertical text, used in the headline here.

While you can use clip art created from most of the popular draw or paint programs or commercial clip-art libraries, Publish It also gives you a built-in draw and paint facility, so you can create graphics within the program. It has reasonable graphics editing capabilities, such as rotate, resize, and reshape, that you can use on either imported bit-mapped and scanned graphics or Publish It–created graphics.

Deciding what to do may be more difficult than doing it. You can use either object-oriented or bit-mapped graphics, with 66 pen sizes, 32 brush shapes, and an airbrush. You can size graphics from 12 percent to 800 percent of their original size, which is probably enough of a range for most users. By contrast, PageMaker allows sizing only from 50 percent to 200 percent of the original size.

The color and texture menus are impressive. You can apply seven transparent or opaque color layers, outline letters in one color and fill with another, create dropped shadows, and use multiple overlay modes (e.g., transparent over transparent, transparent over opaque, and opaque over transparent). The usual options for borders, such as box, rectangle, and double line, are all available as well.

Most helpful for the fumble-fingered among us are the Undo feature, which reverses the last step, and the Group Lock and Align feature. The latter feature lets you freeze an element or group of elements in place on the page you're laying out. Even if you try to lay in a new element that overlaps the "locked" ones, your existing layout won't be ruined.

Publish It also works at a somewhat

continued

Publish It 1.0

Company
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Deerfield, IL 60015
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Documentation
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Inquiry 884.

higher degree of resolution than does PageMaker. It handles kerning, leading, stretching, and condensation of text at resolutions of 0.004 inch. PageMaker's maximum resolution is 0.5 to 5 mm, depending on the specific operation. Likewise, you can rotate, split, and otherwise manipulate graphics objects in increments of 1 degree.

But Publish It doesn't have everything. PageMaker does offer a few more refinements in the handling of scanned images, allowing you to control screening (i.e., the density of dots per inch) and the angle of the scanned image. Publish It lets you rotate an image, but it does not change screening.

In addition, Publish It can import only black-and-white TIFF files; it cannot interpret gray-scale or color TIFF images (Publish It also handles PICT files). The program is also missing the "snap to guides" and "snap to rulers" feature found in PageMaker. This PageMaker function causes elements or frames to align with the layout grid or document rulers automatically.

Overlaid Frames

Like most desktop publishing software, Publish It begins with a blank layout page. On that page, you can locate and define various areas or "frames" (also called elements in some packages), in which you place text or graphics.

You can link frames so that text will flow from one frame to another or so that it can be overlaid (graphics image over text frame). You can also flow text from one page to the next to continue a story, as is the case with PageMaker.

Like PageMaker, Publish It shows "thumbnails" on-screen. Thumbnails are tiny representations of laid-out pages. PageMaker lets you view up to 64 thumbnails at once, so you can see what the bulk of your document actually looks like. Publish It lets you view up to 100 thumbnails (using the scroll bar), but unlike PageMaker, it also lets you edit thumbnails. Granted, the amount of editing you can do on an image that literally is the size of your thumbnail is limited, but you can move frames (e.g., graphics images) from one page to another or reorder pages.

One of Publish It's claims is that it has a fully integrated word processor. It does allow you to type text directly into a defined frame, rather than import it from a text file, but as word processors go, this is nothing to write home about. You can insert and delete, cut and paste, and search and replace text, and you can move around in it with the mouse.

It's far more convenient to construct text files with your favorite word processor and import them. One reason for this is simply the amount of screen space available to work in. You must define a text frame in Publish It before typing in new text, and even in the closest possible viewing mode, you will have less than half the screen available—on a Mac 512KE or SE, this isn't much space.

Also, the cursor keys work oddly in the word processor. Pressing the up arrow always returns the cursor to the beginning of the top line of text, no matter where the cursor is. The mouse, however, lets you move the cursor anywhere in the text frame.

Spelling checking works in either batch mode, checking already typed material or in interactive mode, in which the checker beeps when you type an incorrectly spelled word. You also have the option of checking all "stories" (continuous text pieces, such as newspaper stories) in a document, or checking only selected stories.

The Down and Dirty of DTP

Despite all claims from software vendors, desktop publishing isn't all that easy. It's tedious, messy, and mistake-ridden. However, it is better than doing layout and paste-up by hand.

To make things easier, Publish It has a good on-screen help system with an alphabetically indexed topic list that you can point to and click on. While decent, the help system is not good enough to let you dispense with the user's guide and reference manual. It does, however, include more than 70 sample page layouts that you can use for common publishing jobs, such as newsletters and invoices.

continued

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You can also use multiple "masters." Most desktop packages—including PageMaker—let you use one master at a time to repeat a standard page design from page to page. With Publish It, you can have up to three master pages: standard (which repeats elements on every page), left-only (which repeats elements on left-facing pages), and right-only (which repeats elements on right-facing pages).

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User errors, such as misspelling words or trying to import nonexistent files, are marked only by a beep. Those that required some remedial action from me were adequately explained.

I had minor difficulty, however, in flowing text around a graphical object that overlapped two text frames. Text flowed properly in the second frame, but inside the first frame, the text went inside the graphic, instead of around it.

The problem was apparently due to my not having linked the two text frames together. When I went back several steps (the steps were easily reversible with the Undo feature) and linked the frames, the text flow worked fine.

Better Than PageMaker?

The package comes with 60 days of free technical support. After that, unlimited phone support costs $100 per year. This extended support package gives you a toll-free number, discounts on upgrades and new releases (an upgrade of Publish It is expected within a few months), and product information updates. (The $100 annual support fee also covers all TimeWorks programs in the same hardware format you use.)

The package also has an unusual 90-day money-back guarantee, although this description is a little misleading. You don't get your money back if you don't like the program. But if you find something you like better, TimeWorks says that you can send back your Publish It program disks, your paid receipt, the name of the program you like better, and a check or credit card number for the retail difference between Publish It and the better program; the company will buy the new program for you.

In terms of features and functions, Publish It is nearly the equal of the popular PageMaker. In fact, in view of the built-in draw and paint tools and the extras, such as the spelling checker, thesaurus, and fancy text formatting, this package may offer slightly more to many users.

Of course, not everybody needs to produce, say, "V" text or use many of the other special features in Publish It. Still, at $395, Publish It is quite a bargain. ■

Diana Gabaldon is the editor of Science Software, *which is desktop published, and an assistant research professor at the Center for Environmental Studies at Arizona State University, Tempe, Arizona. You can reach her on BIX c/o "editors."*

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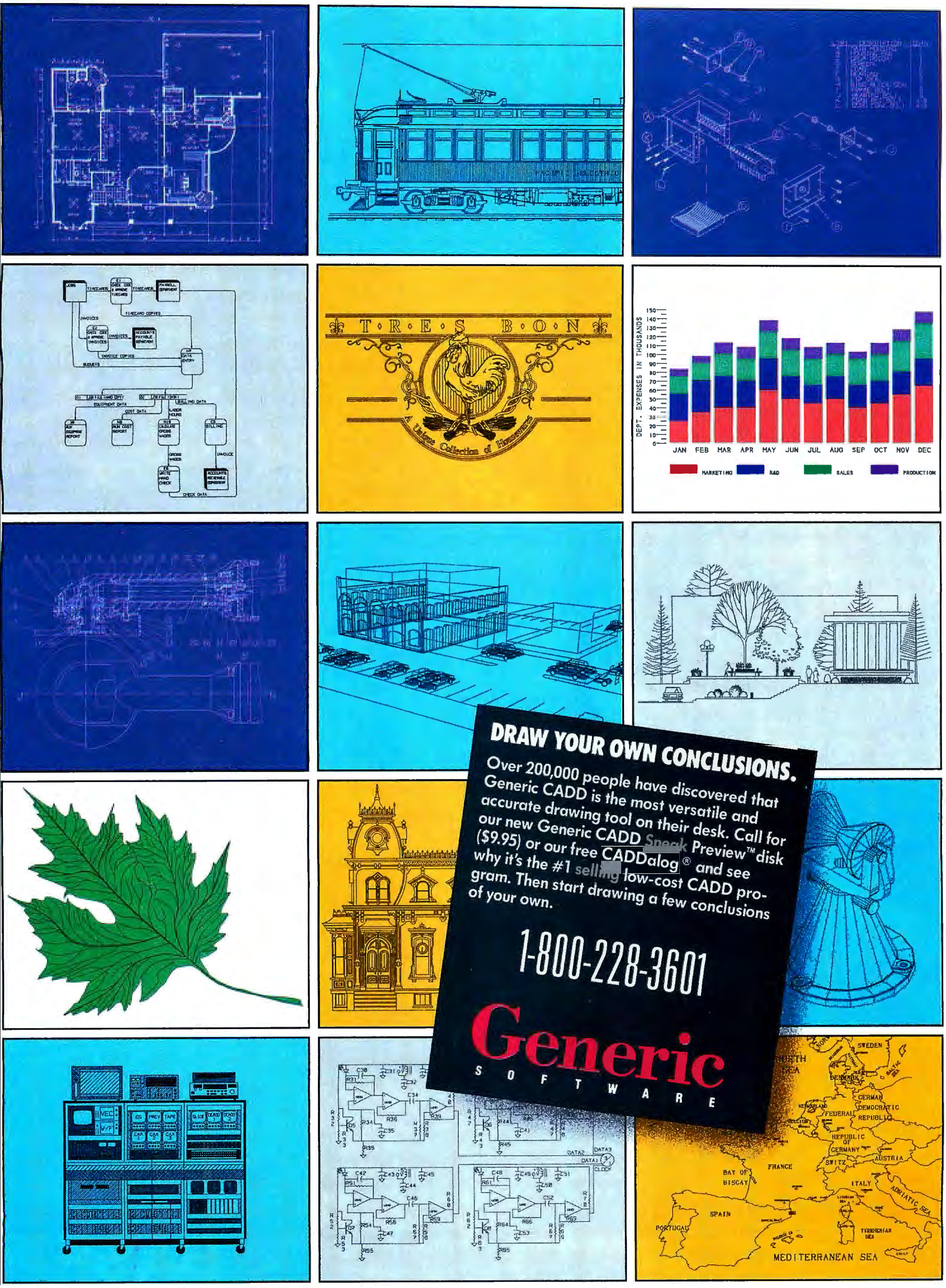
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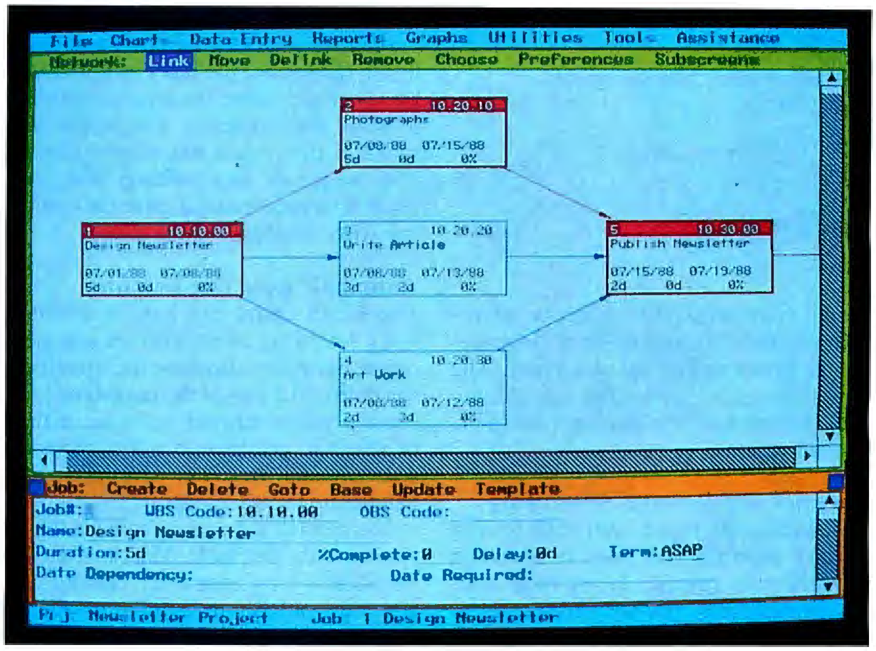
Manage It with Pictures

Project Scheduler 4 is the first midrange, graphically based project management software for the PC

Lamont Wood



Project Scheduler 4 offers an early vision of things to come: graphically based project management.

With Project Scheduler 4 (PS4) from Scitor Corp., you have the leading example of what project management software users have been looking for, and what the market is moving toward: a graphics-based package with a reasonable price and functionality.

Project management is a complex chore. Unfortunately, most project management software can be equally complex. And while many managers get organized by thinking graphically—charting the events of a project on a blackboard—they must then sit down with the software and fill in tables of tasks, resources, and precedence dependencies (i.e., what jobs precede other jobs).

Eventually, the project management software produces a precisely calculated Gantt or PERT (Program Evaluation and Review Technique) chart—basically a born-again version of the blackboard scrawls that the manager began with.

A computer should, of course, do more than augment a blackboard. PS4 still requires you to fill in tables, and you can't draw your Gantt charts directly on the screen. But for $685, PS4 generates a chart that you can play with on the screen. It won't handle the construction of, say, a nuclear submarine, but that's because PS4 is geared to the office environment rather than to construction projects.

Interface à la Windows

PS4 is entirely graphics-based—the only time you're in text mode is when you print reports to the screen rather than to the printer. The command interface is reminiscent of many GEM or Windows applications, although it uses neither. There's a list of menu topics across the top of the screen. Clicking on any of them with the mouse pops up a menu with further commands on that theme. (Operation without a mouse is possible using special key combinations.)

The program has data-entry windows and chart windows. You can enter all the task, resource, and dependency data in tables. Or you can call up the chart windows and enter the data in a "template" that you can invoke in the bottom third of the screen, and watch the chart take form as you go along.

You can set two kinds of charts from PS4: the standard Gantt chart (where horizontal bars represent tasks on a common time scale), and a "network" chart that is basically a PERT chart (where boxes represent charts with connecting lines showing dependencies, with no time scale). Both charts show the "critical path" (i.e., the succession of tasks whose delay would disrupt the entire project) with special highlighting. (Other packages offer variations on this theme—such as Gantt charts with dependency lines—but PS4 sticks to the old war-horse charts.)

PS4 also offers histograms that show consumption of one or more resources over time. You can have either a stand-

continued

Project Scheduler 4 version 1.5

Company
Scitor Corp.
256 Gibraltar Dr., B-7
Sunnyvale, CA 94089
(408) 745-8200

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Software Needed
DOS 2.0 or higher

Documentation
Reference manual; tutorial manual; on-line help

Price
$685

Inquiry 883.

alone histogram with a range of resources, or a histogram for a single resource in a template below a chart. The template version embodies one of the chief advantages of planning with interactive graphics.

Forward and Reverse Scheduling

When doing a project, you have to first specify whether you want to schedule forward or in reverse. If you have a required start date, you schedule forward. If you have a required finish date, you schedule in reverse. Generally, most scheduling is done in reverse.

Then you enter the list of tasks in a table. The data includes a name and an expected duration, in hours, days, weeks, or months. You can also identify each task with a 10-character work breakdown structure (WBS) code or an organizational breakdown structure (OBS) code. You develop these codes yourself to show relationships between tasks, and later sort the tasks. (WBS and OBS are actually the same thing. The idea is that government contractors often have to use the WBS given to them in a contract, and that WBS might differ from their in-house WBS. So they can use the OBS as their in-house WBS.)

You then go to the (still blank) network chart and put the task list in the template on the bottom of the screen, making each task appear as a box at the cursor position in the chart. PS4 handles up to 1500 tasks per project.

You link the boxes together to show dependencies, drawing a line from one task box to the next. (Actually, you can have standard finish-start dependencies, plus start-start and finish-finish dependencies.) There is a data-entry table for showing dependencies, but it's much more fun drawing lines on the screen. As you draw each line, PS4 recalculates the critical path and highlights the boxes accordingly as you go.

At some point, you call down the project calendar (which actually looks like a calendar) and indicate what days of the week you'll be working, as well as what hours of the day (if you're figuring at the hourly level), and denote what holidays you'll observe.

Finally, you can go to the Gantt chart to see (and print) the tasks as horizontal bars, one preceding the other, according to their dependencies. The length and scope of the project are clearly visible, with weekends and holidays and even lunch hours accurately figured in (and, if you wish, displayed on the chart).

Automatic Resource Leveling

The Gantt chart can have dependent tasks following each other in a logical order, but it can also have the same person doing 10 things at the same time. Assuming you're scheduling for more than one person, you have to worry about resources—and "resource leveling." PS4 handles up to 500 resources.

You can fill out a resource table that is similar to the task table. You can even use an identifying resource breakdown structure, or RBS, in a similar manner to that of the WBS or OBS. Each resource also gets a cost in dollars per hour, day, week, or month. The amount can be zero, but PS4 has to know what time period you want to use for scheduling. Also, you must state the availability—if the cost is per hour, then you might state an availability of 40 hours per week.

Each individual resource can have its own calendar for figuring vacations and other variations. But you have to be careful. If a person assigned to a task goes on vacation during that task, PS4 delays the task's completion until that person returns. This makes sense—by assigning the person, you indicate that the task can't proceed without him.

More complications arise when you start assigning resources to tasks. You can set up PS4 to figure the task duration on the basis of the assigned resources. For example, if the task had an expected duration of 8 hours and eight people are assigned to it, then that task's duration will automatically change to 1 hour. Or it can be set up to figure total input (e.g., eight people working 8 hours on a task means 64 work hours were spent). You can also have it calculate work rates to show that your eight people will have to work 8 hours a day collectively to finish the 64-hour task in eight days.

The task-duration method might be preferable for scheduling construction-like projects, where tasks can be defined in work hours and scheduling is a matter of covering tasks with enough people to get the tasks done by a certain time. The problem with the task-duration method is that PS4 does not record your original work-hour calculation. If subsequent adjustments in the schedule change the duration again, your original calculation will be lost.

After you assign all your resources, next comes "resource leveling," which means making sure everyone (or everything—a resource can be a bulldozer or a sum of money) is doing only one thing at a time. This can be done manually or automatically.

Manually, you can call up histograms—one for each resource—in a template at the bottom of the Gantt chart and see if any of the bars in the histogram jut above the line (meaning overcommitment for that time frame). The histogram is shown on the same time scale as the Gantt chart, and only the tasks involving that resource are shown. Therefore, any problem task will be just above the line. The histogram template has a useful "search" command that searches the list of resources for overcommitments. Each time you invoke it, PS4 finds the next overcommitment.

You can then use the extend or delay commands to move or lengthen the task in question—actually adjusting the bars with the mouse—to alleviate the problem. (Or you can add a delay value for that task in the task table or change its duration.) As you make each change, the other bars will rearrange themselves according to the precedences.

The automatic resource leveling command removes the overcommitments automatically. The use of automatic resource leveling is somewhat controversial among project management software vendors, since there is no good way to do it, and the resulting schedule may have tasks shoehorned together in ways that would be unmanageable in real life. However, it can quickly provide a workable schedule, which you can then adjust manually.

Baseline Tracking and Analysis

After it makes your schedule, PS4 can generate a "baseline" for a finalized

continued

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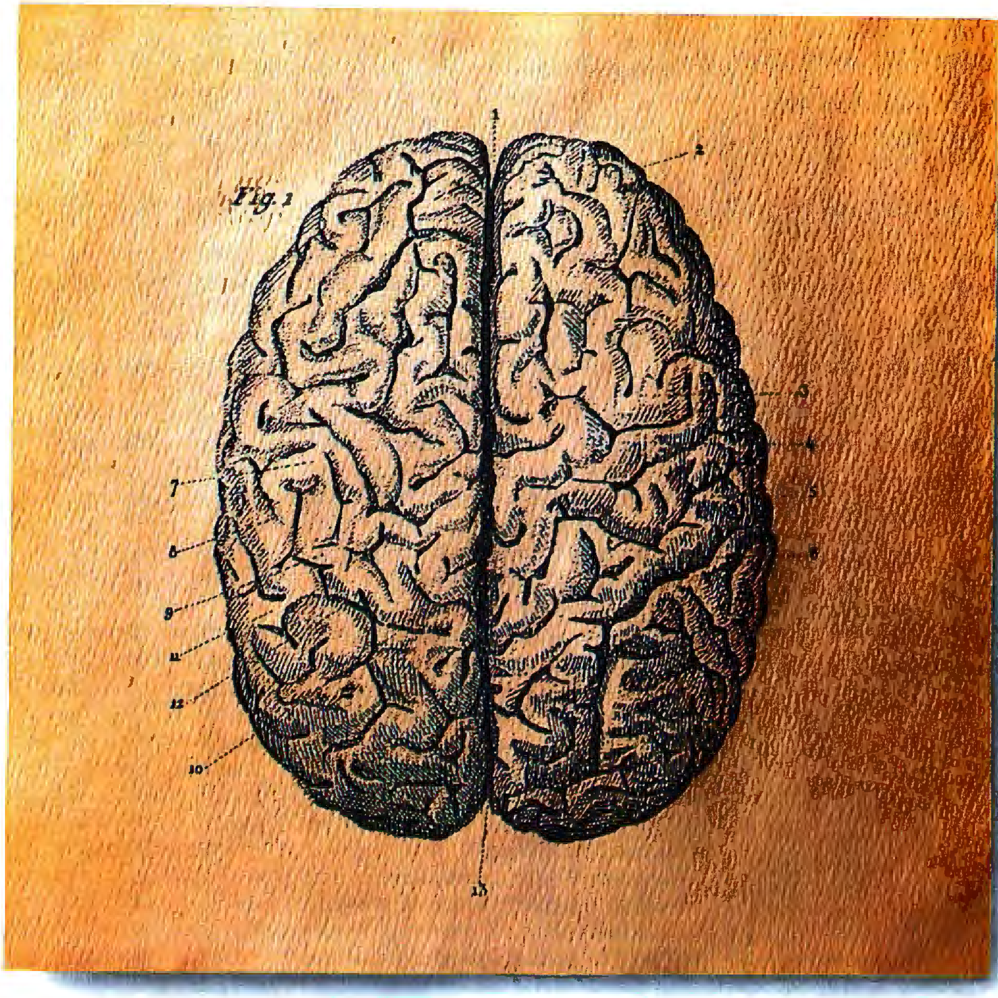

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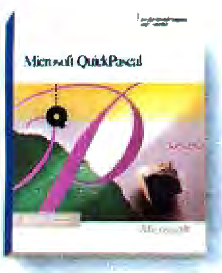

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schedule. The PS4 shows the original place of each task on the Gantt chart as a dark bar.

At this point, if you scheduled in reverse, you will want to change the setting to forward scheduling, which fixes the start date. Subsequent alterations can push back the end date, which is no longer fixed, but the slippage will be noted on the Gantt chart.

Here you can run into a problem with any task that had a specific start date or deadline. (You enter these dates with the data that goes into the task template.) The start date and the deadline date are simply reversed when you switch from reverse to forward scheduling. But if you must do serious rescheduling during the tracking phase, you'll have to go into the templates and change all those dates—something you might not care to do.

PS4 will also let you do a "PERT analysis" on the schedule. You give three time estimates for each task—optimistic, pessimistic, and most likely. The software then comes up with an average estimate. You can vary the importance given to each of the three estimates.

On the resource table, you can enter expected inflation values and the start dates for those values. You can, for instance, see if stretching out a project will actually save you money if, say, the workers involved are all likely to get raises in the meantime.

PS4 comes with a stand-alone data conversion program (which also uses a GUI) called IMEX. It converts between the PS4 file format and those of Lotus 1-2-3, dBASE III Plus, and comma-delimited ASCII.

On-Line Help

PS4 has so many help features that its printed documentation is superfluous after you finish the installation.

There are three on-screen help modes: standard, terse, and assist. In standard mode, you get a screen message for every error. In terse mode, you get only beeps for most errors. With the assist mode, you get a pop-up message every time you invoke a menu or need to make a choice. I quickly felt pestered by it and switched to the standard mode.

Another command brings up an on-screen version of the reference manual. Its organization closely parallels that of the printed reference manual, but the material is more terse. If you are within a command when you invoke the documentation, it takes you to the start of the section dealing with that command. Otherwise, it opens in the table of contents, and you use its GO TO command to navigate from there.

If you don't like using on-line help, there is the printed reference manual, plus a tutorial manual that includes a skeletal discussion of project management concepts. Ironically, it could use more graphics—the only key to the Gantt chart symbols I saw was the one that PS4 adds to the printed version of the chart.

A Question of Management

PS4 borrows ideas from some of its more expensive cousins, such as Pertmaster International's Pertmaster Advance, especially the ability to level manually using a split screen. But PS4 remains a midrange package with midrange capabilities. It lacks, for instance, an outlining feature whereby you can add details as they come to mind. There is no way.to input actual completion dates for individual tasks during the tracking phase, which can be important when dealing with subcontractors.

Also, the idea of using forward and reverse scheduling seems unnecessarily complicated—most packages will attempt to level a schedule within given deadlines and run up a flag if that proves impossible. PS4 pushes the start or end date if there's a leveling problem, and it flags the variance. The way it handles the duration of tasks may also make you nervous if those durations are the result of complex on-the-side calculations. Otherwise, if the duration needs to be what you say it is, you'll like the precise control PS4 gives you.

On the other hand, the program is very fast; rarely do you have to wait for anything. Running PS4 on even an IBM XT is reasonable. It's also friendly, with its help modes and graphics.

But project management is like word processing. Everyone's needs are so idiosyncratic that you can't have a package that is all things to everyone. PS4 is best suited to middle-level managers who occasionally need a quality project management package with enough friendliness to slash the learning curve. And it's certainly better than a blackboard. ■

ACKNOWLEDGMENT

I wish to thank consultant Daniel Yahdav, president of 1 Soft Decision, Inc., in San Rafael, California, who provided input on this review. He publishes PM Solutions, *a decision-making tool for selecting project management software.*

Lamont Wood is a freelance writer in the computer and electronics fields and lives in San Antonio, Texas. He can be reached on BIX as "lwood."

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PC MAGAZINE EDITOR'S CHOICE
March 14, 1989

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What Price Color PostScript?

Thanks to the speedy QMS Model 10, the cost of color PostScript printers continues to wane

Howard Eglowstein

With a fast 68020 processor and color PostScript capability for under $10,000, the QMS ColorScript 100 Model 10 carves new territory for wax-transfer printers.

Like its big brother, the Model 30, the ColorScript Model 10 produces color images with a roll of Mylar ribbon alternately striped with bands of yellow, magenta, cyan, and black wax. A host computer sends color PostScript commands to the printer through a serial or parallel interface on PCs, or through a DB-9 LocalTalk connector on Macintosh networks. The 68020 processor in the Model 10 runs the commands through the PostScript interpreter and generates four-color separations.

Image for image, the QMS Model 10 matches the print quality of more-expensive printers. The high-performance processor enables the printer to blow the doors off the competition. But color printing doesn't come cheap. Hard copy from the Model 10 costs about eight times as much as black-and-white output from a standard laser printer.

More Expensive Than Crayons

The $9995 base price includes 4 megabytes of image RAM; the serial, parallel, and AppleTalk connectors; 35 resident fonts; 30 sheets of coated paper; and a short ribbon. Full-size ribbons cost $105 each. Coated paper runs to $125 for 2000 sheets; transparency sheets are $125 per 100.

Three options are available: extra RAM, external hard disk drives, and Hewlett-Packard Graphics Language (HPGL) emulation software. The extra RAM lets you download more fonts or create larger images in printer memory. The $1495 4-megabyte upgrade allows for both legal-size printing and more downloaded fonts. The 20-megabyte and 40-megabyte external hard disk drives ($995 and $1495, respectively) connect to a SCSI port on the back of the printer. They enable the Model 10 to automatically cache fonts as needed or to store downloaded fonts for quick retrieval.

The HPGL emulation software ($199) is a PostScript program that you download to the Model 10. From that point on, your application sends plotter commands that would normally control an HP 7475 or compatible (HPGL) plotter. I had difficulty getting the software to run on our base model printer. It handled simple images, but it choked on fairly complex images. I suspect that I needed more than the standard 4 megabytes of memory to run this emulation.

Blazing Speed

I tested the Model 10 against the ColorScript Model 30, the Tektronix Phaser CP (see "Color by Numbers," July BYTE), and the Apple LaserWriter IINT. Each printed the benchmark files used in our Product Focus on PostScript printers (see "PostScript Printers Come of Age," September 1988 BYTE). The Model 10 converts PostScript commands to an internal bit map with impressive speed, as the PostScript graphics test demonstrates (see table 1). Generally, the Model 10 performed better than the

continued

more expensive Model 30 and held its own against the Phaser in all but the large-text-file print test.

The wax-transfer process requires the Model 10 to roll the paper through the printer several times, one for each color on the ribbon. The printer grabs a sheet of paper from the stack and rolls it in. The paper comes out the output tray, the ribbon advances, and the printer draws the paper in again. When the paper reappears, you see the yellow portion of the image. Successive passes build the image before the paper is finally released into the output tray. Because our PostScript test files are black and white, the Model 10 had to roll through all four ribbon colors just to use the black band.

After evaluating the printer's speed with the color ribbon, I also tested its performance with an all-black ribbon, which allows you to use the ColorScript without wasting expensive color ribbon. With a monochrome ribbon, the Model 10 ran significantly faster than the LaserWriter on both the large-text-file and the graphics tests. Both printers use Adobe PostScript, so the speed difference has to be related to processing power—the LaserWriter's 11.5-MHz 68000 is simply no match for the Model 10's 16.7-MHz 68020 processor.

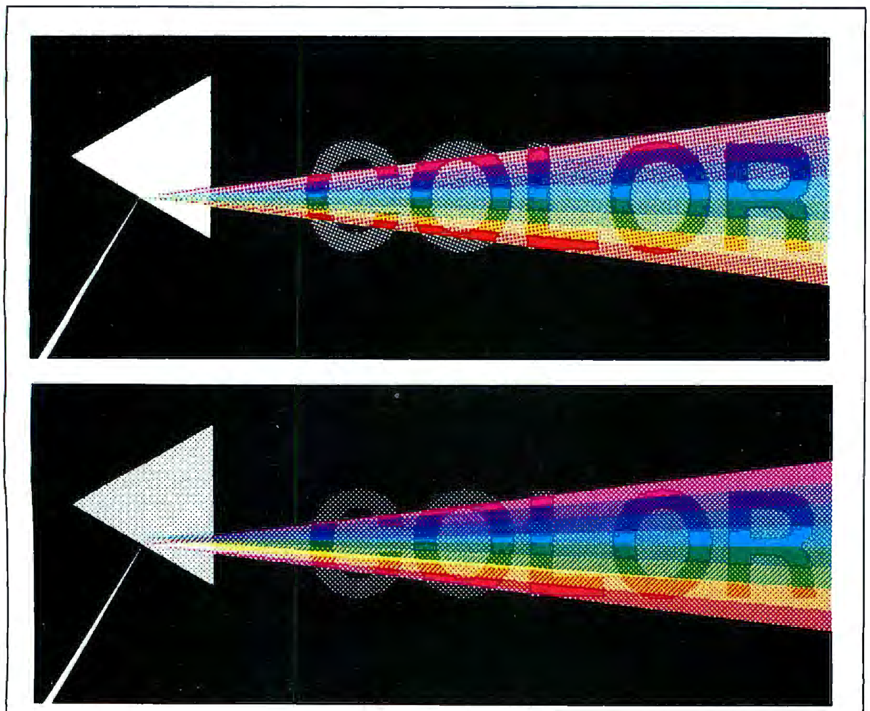
In addition to speed, the Model 10's print quality looked excellent for a wax-transfer printer. I ran Adobe Illustrator and PageMaker 3.0 on both a Mac II and an AT compatible. Both applications took advantage of the ColorScript's full range of colors. Your application will determine the amount of color you get. The fonts could be crisper, but you shouldn't consider this printer as a substitute for laser printing or for generating final color output—it's good, but it's not that good. Still, the output matched that of the Model 30 and proved comparable to that of the Tektronix Phaser CP, which costs about $2000 more (see figure).

Table 1: *Running BYTE's PostScript-printer benchmark files, the ColorScript 100 Model 10 logged impressive speeds, especially when converting PostScript graphics commands to an internal bit map. (All times are in seconds.)*

FOUR-COLOR SPEED

Printer	Large text file[1]	Small text file[2]	PostScript graphics file
Apple LaserWriter IINT	484	131	203
ColorScript Model 10, mono ribbon	344	127	41
ColorScript Model 10, four-color	874	328	99
ColorScript Model 30	1582	362	297
Tektronix Phaser CP	640	380	285

[1] Consisted of a 125K-byte, 16-page file that contained seven fonts.
[2] Consisted of a 25K-byte, six-page file with three fonts and small graphical elements.



ColorScript Model 10 hard copy (top) matches the quality of that of the more expensive Tektronix Phaser CP (bottom). Both printers use wax-transfer printing technology to achieve superb output.

Who Needs Color?

This printer makes sense for people who need color proofs or small numbers of high-quality color copies. QMS expects the printer to be popular with desktop publishers and others who need quick access to color hard copy. I can imagine it being used, for example, in real estate offices for listings sheets and in businesses that prepare color transparencies for presentations. It's also ideally suited for artists using desktop computers for layout and design. Because it supports PCs and Macs equally well, network installations may be the best application for it.

Accordingly, I envisioned that some of these professionals might print a number of proofs, stuff them into the trunk of a car, and drive off to meet a client. Would the wax on the printed copy melt and stick the pages together if the car were left in the hot summer sun? I stacked some hard copies from the Model 10 in BYTE's environmental chamber and set it at 140°F. After 5 hours in our car-trunk simulation, the color images were as clear and bold as ever, and the stack of wax printouts didn't melt together.

Cashing in on Color

Although attractive, the Model 10's under-$10,000 price isn't the whole story. A four-color, letter-size copy from the printer costs about 68 cents. By comparison, standard laser printers churn out black-and-white images for 8 cents a sheet or less. Even with the monochrome ribbon, a black-and-white copy from the Model 10 costs about 25 cents, three times the price of a copy from a standard laser printer.

Also, the "optional" 1-megabyte upgrade is necessary if your work re-

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Circle 63 on Reader Service Card

QMS ColorScript 100 Model 10

Company
QMS, Inc.
One Magnum Pass
Mobile, AL 36618
(800) 631-2692

Features
Full four-color printing (wax transfer); standard AppleTalk, parallel, and serial interfaces; SCSI connector for external hard disk drive; 4 megabytes of RAM standard, expandable to 8 megabytes; 16.7-MHz 68020 processor; Adobe PostScript interpreter; 35 resident fonts; 300-dpi print resolution; HPGL emulation available; handles letter, legal, and A4 media sizes (paper or transparency material); Pantone certified

Size
11⅓ × 17 × 24⅘ inches; 65 pounds

Hardware Needed
MS-DOS computer with serial or parallel interface; Macintosh II family; any other computer capable of generating PostScript commands to a standard serial or Centronics parallel interface

Documentation
Owner's manual

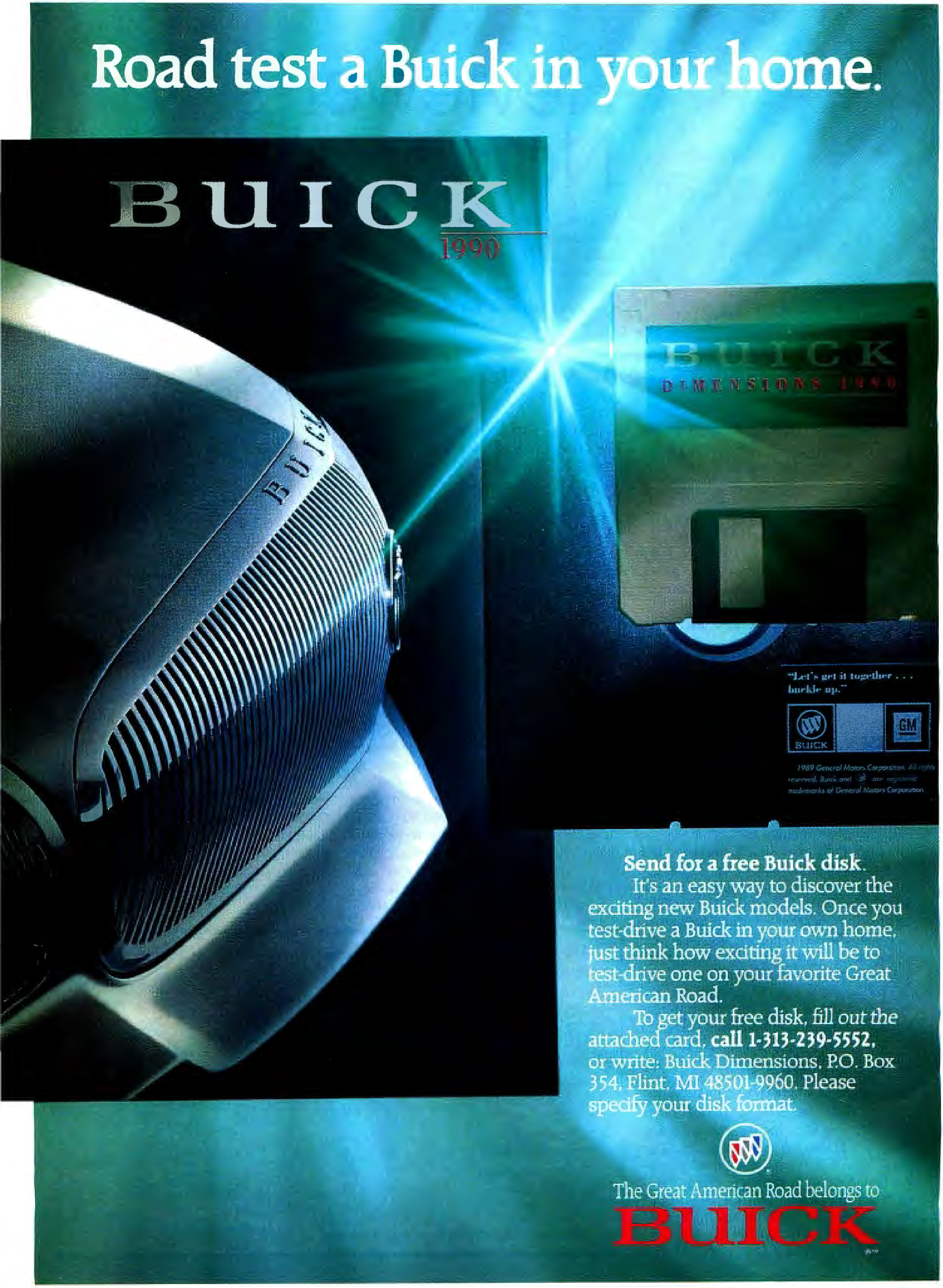
Price
As tested with 4 megabytes of RAM: $9995

Inquiry 861.

quires you to print full 8½- by 11-inch color images. Because of the precision needed to keep the four color passes aligned, the printer takes a 1⅓-inch bottom margin and a 7/10-inch top margin off each sheet of paper. This crops standard-size pages to an effective printing area of 8 1/10 by 9 inches. You could handle this by using legal-size paper, where the printable area becomes 8 1/10 by 12 inches. I tried this on our base model, but the standard 4 megabytes wasn't enough. If you need to print a full page, 5 megabytes of memory is a minimum configuration.

In general, the ColorScript 100 Model 10 is well built, relatively inexpensive, and reasonably fast. Color PostScript capability is clearly not for everyone. Even at $9995, the printer's price will keep it out of reach as a personal printer for most people. However, this technology is likely to become more appealing as the price of wax continues to wane. ■

Howard Eglowstein is a testing editor for the BYTE Lab. He can be reached on BIX as "heglowstein."



Circle 53 on Reader Service Card

Reviewer's Notebook

Reviewer's Notebook is a compilation of brief reviews and updates to previously published evaluations. BYTE will publish Reviewer's Notebook each month on a space-permitting basis.

Update: Standout Graphics Board

In November, BYTE's Product Focus spotlighted coprocessor-based graphics controllers for mainstream PCs. Since then, we've tested another 34010-based board, the Rendition II from Renaissance, which proved itself among the top performers in this product class.

The Rendition II is a medium- to high-resolution (1024- by 768-pixel) graphics controller for IBM ATs and compatibles. The $1495 base model includes 512K bytes of video RAM, enough for 16 simultaneous colors at full resolution. Renaissance also sells a 256-color board with 768K bytes of VRAM for $2095. Each model offers a 24-bit color lookup table for a 16.7-million-color palette.

In addition to frame-buffer memory, the board provides sockets for up to 512K bytes of DRAM; the base model comes with 128K bytes installed. DRAM can be used to store 34010 downloadable instructions, or any data shared by the 34010 and the primary processor.

Although Renaissance supports the Texas Instruments Graphics Architecture 340 interface, TIGA drivers for the Rendition II are still in the works. The standard application interface now shipping with the board is IBM's 8514/A AI. Renaissance also offers its proprietary graphics interface to developers.

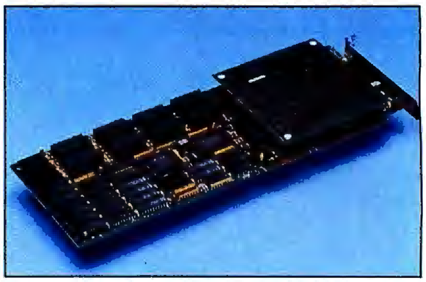
The board arrives bundled with a wealth of drivers for specific applications, including Gem/3, Ventura Publisher, and Microsoft Windows. Renaissance also provides display-list drivers for AutoCAD releases 9 and 10, VersaCAD, and MicroCADDs GCD. You'll need additional hardware to run under standard graphics modes, because the Rendition II doesn't do emulations. The board can coexist with a standard graphics board, and it supports VGA pass-through for single-monitor operation. You can also buy a VGA daughterboard ($300) to save an expansion slot.

I ran our AutoCAD release 10 and PageMaker tests with the Rendition II in the same Compaq 386/20 that we used for our Product Focus. Table 1 compares Rendition's performance with that of two of the best boards from that review, Number Nine's Pepper Pro1280 and Compaq's Advanced Graphics 1024.

The Rendition II keeps the AutoCAD display list in on-board memory, splitting it between available DRAM and video RAM. The unit I tested had 384K bytes of DRAM and 1 megabyte of VRAM, with 768K bytes required for the frame buffer. If EMS memory is available, the board can use both on-board and expanded memory. The driver can also write the information to disk.

CAD performance was excellent. The driver maintained display lists for the large and small drawings. Times approximated those of the Compaq Advanced Graphics 1024 board. The Rendition's PageMaker test performance also came close to the Compaq's, which topped our list of 1024- by 768-pixel boards. The screen display was clear and readable, and the driver had no noticeable flaws.

Overall, the Rendition board is excellent for medium- to high-resolution graphics. Besides speed, reasonable price, and a good-looking display, it offers some slick extras. An automatic self-test routine, easy driver-configuration utilities, and solid documentation round out the package.—*Steve Apiki*



The Rendition II provides 1024- by 768-pixel resolution and some slick extras.

Rendition II
Renaissance GRX, Inc.
Cedar Park
2265 116th Ave. NE
Bellevue, WA 98004
(206) 454-8086
$2993 as reviewed
Inquiry 854.

Table 1: *Rendition II holds its own against the top coprocessor-based graphics controllers. (All times in seconds.)*

TOP 34010 BOARDS

	AutoCAD Small drawing			AutoCAD Large drawing			PageMaker	
	Redraw	Zoom	Pan	Redraw	Zoom	Pan	Scroll	Zoom
Renaissance GRX Rendition II	2	6	5	3	8	7	12	4
Number Nine Pepper Pro1280	2	2	3	5	4	4	9	5
Compaq Advanced Graphics 1024	2	6	5	3	10	8	11	4
Compaq VGA*	7	11	9	12	16	14	21	2

*Results for a Compaq VGA card are shown for comparison.

Mac Color by SCSI

Aura Systems' ScuzzyGraph II brings higher resolution and color to the Mac Plus and SE. ScuzzyGraph is an external graphics display that plugs into the SCSI port and lets you connect with large-screen monitors. To install it, you configure a few jumpers, place the unit under your Mac, connect the SCSI cable, and turn on the power.

ScuzzyGraph is fast. Its dual processors (a 10-MHz 68000 and a 40-MHz 34010) render the QuickDraw eight-color set as fast as the Mac normally displays black and white. The reviewed Model IIm/8a gives 720- by 512-pixel resolution on an NEC MultiSync.

The INIT diverts QuickDraw calls from the screen to the ScuzzyGraph. It works well if your software supports QuickDraw. The list is short; ask Aura if it includes your favorite programs.

Our test unit showed one weird characteristic. When printing to a PostScript printer, the ScuzzyGraph intercepted the QuickDraw calls meant for the printer driver and rendered the print image on-screen. The Mac printed the image accurately, but the screen image was partially obscured with pieces of the print image.

A more serious problem, and one beyond Aura's control, relates to color printing. Most color printers want to see Color QuickDraw before they can print in color. The Mac SE doesn't have it, and applications will still print in black and white. The ScuzzyGraph will display color, but you may not be able to print it.

I'd like to see a monochrome version— and some protection for the power-supply connections inside the case. If you open the case while the unit is plugged in, you can get a nasty shock.

ScuzzyGraph isn't cheap. The digital-only version starts at $995 for resolutions of up to 720 by 512 pixels. Aura's most expensive model ($2495) supports monitors with resolutions of up to 1280 by 1024 pixels. By comparison, Orchid's ColorVue SE display board costs $695. The more expensive ScuzzyGraph runs faster and works with the Mac Plus. If you later want to upgrade your Mac SE to an SE/30, the ScuzzyGraph can tag along and provide color for that as well; ColorVue won't fit into your upgraded Mac.

Before investing in a ScuzzyGraph, SE owners may first want to speed up their machine's processor. Apple offers an upgrade from a Mac SE to an SE/30. Then you can choose an internal color board and get real Color QuickDraw.

Mac Plus owners who don't plan to upgrade to a faster Mac may have more reason to take a look at ScuzzyGraph II.

—Howard Eglowstein

ScuzzyGraph II
Model IIm/8a
Aura Systems, Inc.
P.O. Box 4576
Carlsbad, CA 92008
(619) 438-7730
$1195
Inquiry 852.

Update: Plotter Redux

In our Product Focus on plotters last year ("Plotters in Perspective," December 1988), we voiced serious reservations about the overall poor performance of United Innovations' (UI) wall-mount Mural 8000 plotter. Since that time, the company has embellished its plotter line with options that encouraged us to take a second look.

UI has resolved one of the noted weaknesses, manual pen changing, with the eight-pen Auto-Select option. The $495 add-on attaches to the side of the Mural 8000 (sizes A–D) and Mural 9000 (sizes A–E) to automate pen changes. A four-pen Auto-Select ($395) is available for the Mural 7000 (sizes A–C). Auto-Select also includes the Sure-Flo test pad: When a new pen is selected, it draws on a scratch pad, ensuring smooth pen flow before drawing. This slows down a multicolor plot, but you can disable the feature with the flick of a DIP switch.

Another option is a pen holder that attaches to the pen arm and accepts a wide range of writing instruments, including large magic markers. This makes the Mural 8000 ideal for drawing signs.

The Mural 8000's flatbed design and its new options make it one of the most versatile large-format plotters around. It will accept any medium (including posterboard and plywood) up to a quarter of an inch thick. Its open sides accommodate especially long media. With included software, you can complete part of your drawing, slide the media through to the next section, and then continue the plot. Similar attachments accept drafting pencils or a digitizer sight.

The revamped Mural 8000 plotter now offers optional automatic pen changers and new pen holders (inset).

The plotter should appeal to those who require nonstandard media or special writing instruments, as well as those whose plotters handle a wide range of jobs. Even with the options, the Mural 8000 is relatively inexpensive, with a base price of $2495. A utilities disk that comes packaged with the plotters includes some useful programs for digitizing, resizing plots, and converting between the Hewlett-Packard Graphics Language and other formats.

Mural 8000 has some weaknesses; it's slow, and mounting the paper with double-sided tape is awkward. But the tradeoffs that UI has made keep the price low.*—Stanford Diehl* ■

Mural 8000
United Innovations
171 Interstate Dr.
West Springfield, MA 01089
(413) 733-3333
$2495
Inquiry 855.

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w/80MB (28ms) & 1:1 Interleave	$2749	$2798	$2948	$3248
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Vertical Case Option for 386/20 w/230W power supply add $300

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w/48MB (28ms) & 1:1 Interleave	$1899	$2048	$2198	$2498
w/80MB (28ms) & 1:1 Interleave	$2249	$2298	$2448	$2748
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w/48MB (28ms) & 1:1 Interleave	$1399	$1448	$1798	$1898
w/80MB (28ms) & 1:1 Interleave	$1749	$1798	$2148	$2248

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Dual Floppies	$779	$949	$1178	$1278
*w/32MB (40ms) Hard Drive	$979	$1149	$1378	$1478

* Includes Single 360K Floppy Drive
† Upgrade from 12" to 14" Flat Screen, add $49

Standard Features	386/33	386/20D	386SX	286/12	XT10
CPU	80386	80386	80386SX	80286	8088-1
Speed (MHz)	33/8	20/8	16/8	12.5/6.25	10/4.77
BIOS	Phoenix	Phoenix	Phoenix	Phoenix	Phoenix
Norton SI Rating v 4.0	41.8	22.0	17.6	12.3	2.1
Standard Memory	1MB	1MB	1MB	512K	640K
Shadow BIOS	Yes	384K	Yes	Yes	—
Memory Upgrades	2/4/5/8/16MB	2/4/8/10/16MB	2/3/5/6/8MB	640K/1/2/3/5MB	—
Coprocessor Support	80387 or 3167	80287 or 80387	80387SX	80287	8087
Expansion Slots: 32-bit	1	1	—	—	—
Expansion Slots: 16-bit	5	4	6	6	—
Expansion Slots: 8-bit	2	3	2	2	8
Dual HD/FD Controller	Yes	Yes	Yes	Yes	w/HD systems
5.25" Floppy Drive	Standard	Your Choice	Your Choice	Your Choice	Standard
3.5" Floppy Drive	Standard				Optional
Device Bays (Exposed/Internal)	6 Exp.	3 Exp./2 Int.	3 Exp./1 Int.	3 Exp./2 Int.	2 Exp./2 Int.
Serial Ports	2	2	1	1	1
Additional I/O Ports	1 Parallel	1 Parallel	1 Parallel	1 Parallel	1 Par/1 Game
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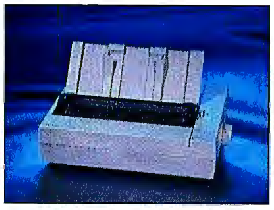

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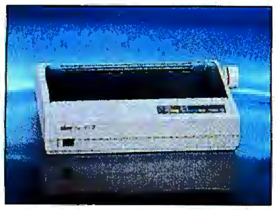

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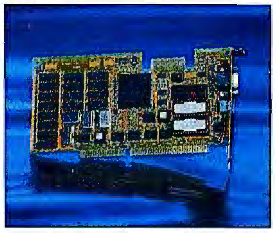

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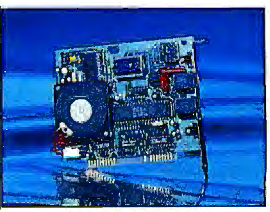

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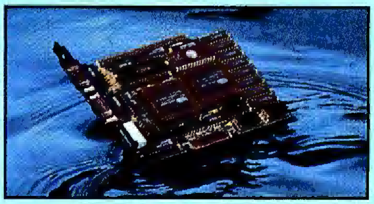

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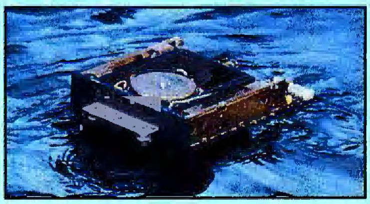

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Sound and Image Processing

From the sound-and-light spectacles in the Roman Forum to the latest Indiana Jones adventure, sounds and images just seem to go together. Sound adds emotion to simple images, and images create a frame of reference for sound.

You could argue that true art stands alone and that fine music lets your spirit soar on its own journey. Both of these statements are true, but in our normal everyday lives, those of us who can will usually choose to combine the two. How many of us choose silent movies over those with sound as a regular diet?

A while ago, I heard a radio playing some lovely harpsicord music. I went exploring. What I found surprised me. What I had heard wasn't a radio at all—it was the NeXT machine. I really couldn't tell the difference. But I found out what the difference was—a digital signal processor. The NeXT machine has a DSP built in for sound processing.

Times have changed. No more stilted mechanical-sounding output. Until recently, sound and image processing involved very different technologies. Now, DSPs have become the unifying factor between the two. Both can use DSPs to improve output quality.

The first article in this In Depth section, "Sounds and Images," is a series article that provides the "big picture" for both sound and image processing and establishes their relationship to DSPs. The first section, "Sounds" by Gene Smarte, discusses both voice recognition and music. The second part, "Images" by Walt Penney, looks at what is possible in image processing on a microcomputer.

Next, Bobby Saffari goes into more detail about DSPs in "Putting DSPs to Work." He explores floating-point application-specific-IC DSPs, what they do, how they do it, and their relationship to—and uses in—both sound and image processing.

Then, in "Beyond Pattern Recognition," Raymond Kurzweil looks at advances in voice-recognition technology. He shows how voice-to-text systems rely at least as much on knowledge engineering as they do on voice recognition.

In "Changing Perceptions of Reality," Benjamin M. Dawson examines image editing. He provides descriptions, formulas, and in some cases code fragments for various image-editing techniques.

Finally, in "Pepperoni and Paperwork," Ira Scherr ties it all together. He describes a voice-activated document-delivery system that starts with a telephone call and ends with a fax printing out on your desk. From voice recognition to document image processing, this article brings home the practical applications that are possible when you combine sound and image processing.

Few of us are likely to work on the next chapter in the *Star Wars* saga, but we can find practical uses, as well as some fun ones, for various aspects of sound and image processing. Image processing as an industry is taking off. And with DSPs coming into their own, can sound processing be far behind? The uses and combinations of the two are virtually limitless—from science fiction to business fact.

—Jane Morrill Tazelaar
Senior Technical Editor, In Depth

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Sounds and Images

From music to medicine, from voice to video, sound and image processing are now real on microcomputers

The elusive dream of AI, something that has yet to materialize in a substantial form, is an ongoing quest for both software and hardware designers. But some of our five primary senses have been replicated with mixed results. For some specialized tasks, mechanized sight, hearing, and speech have emerged at levels that are competitive with, and sometimes beyond, those of flesh and blood. For most other kinds of tasks, however, these computer-based "senses" are still woefully inadequate.

Computer-based image enhancement and manipulation are commonplace, enabling us to "see" and record things impossible to see with our eyes. We can look across a galaxy with the aid of charge-coupled devices or electronically delve into the human body via computer-aided tomography. Yet a computer-based machine can have trouble picking out a monkey wrench on a workbench if the wrench's shape differs slightly from that of the one used to train the system.

Computer-based sound processing ranges from automating repetitive messages to giving voices to the verbally disabled. Symphony orchestras can now reside on silicon chips. Electronic music capabilities have opened doors so that nearly anyone with an interest in music can become more deeply involved in its creation and production than ever before.

Voyager's August flyby of Neptune yielded megabyte after megabyte of digitized photo data. Through noise-canceling techniques, the addition of false color, and other enhancements, intimate details of Neptune began to emerge. While the computers used at the Jet Propulsion Laboratory generally are not what most of us have on our desks now, a similar degree of image-processing power awaits us in the near future.

A more down-to-earth example of image processing in everyday activities is shown in a legal case involving a disputed claim as to the safety of a rifle's firing mechanism. Evidence submitted included a carefully crafted, precisely scaled, videotape version of the rifle's firing mechanism in action. The mechanism in question had tolerances in the range of thousandths of an inch, and, hence, the CAD-constructed video presentation had to maintain these tolerances as the operating image was enlarged to show details. The court found that this sort of presentation provided a way of displaying the operation of an intricate mechanism to a nonexpert jury while still satisfying the expert witnesses.

Digital Signal Processing

A very important trend in the manipulation of image and sound information is the emergence of digital signal processor

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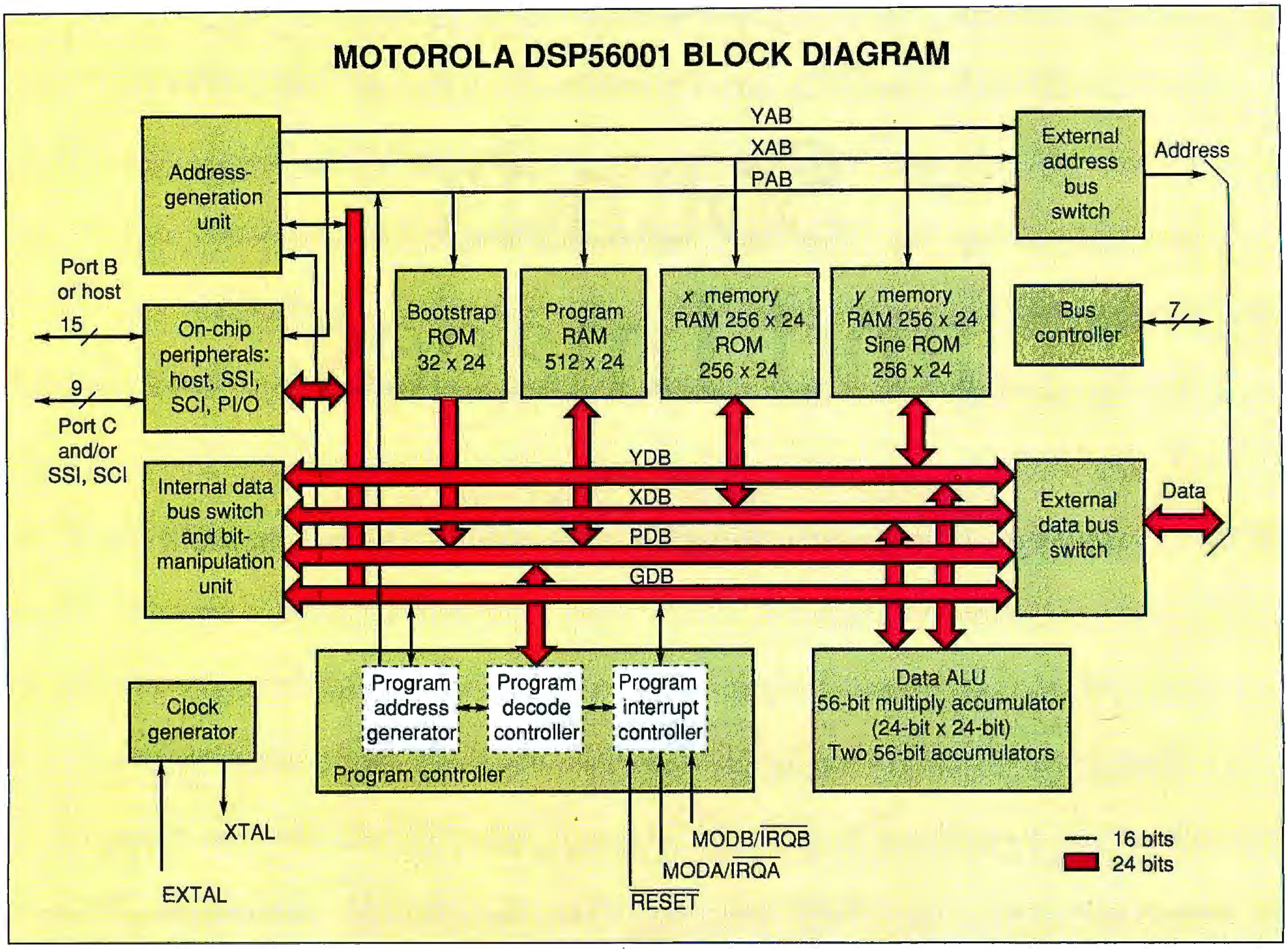

Figure 1: *This digital signal processor chip uses a 24-bit data path and operates at 20 MHz to provide 10-million-instruction-per-second performance. (Courtesy of Motorola, Inc.)*

(DSP) chips from such companies as AT&T, Fujitsu Microelectronics, Motorola, Texas Instruments, and NEC. You can think of them as siblings of the older and more specialized math coprocessor chips that are becoming more and more commonplace.

Now, for example, instead of off-loading only the math-related computation-intensive parts of a program, you can call on a DSP to massage data while the host processor executes other less-specialized tasks. Companies use DSPs for projects such as real-time data filtering, speech synthesis and voice recognition, and image and graphics processing. The NeXT computer includes an on-board DSP; this might be the beginning of a trend toward flexible and powerful on-board signal processing.

While many differences exist among the various manufacturers' DSPs, more characteristics are common than different. For example, in addition to some sort of on-board arithmetic processing, they all contain some internal processor control and an interface to the host. Most DSPs have a full-blown instruction set with lots of complicated math and usually some functions unique to each chip. Some have C compilers.

As an example, take a look at a block diagram of Motorola's DSP56001 chip, shown in figure 1. Motorola specifies this 88-pin high-speed CMOS device as a

A DSP massages data while the host processor executes less-specialized tasks.

"56-bit general-purpose digital signal processor." Running at 20 MHz, it's capable of operating at over 10 million instructions per second with 24-bit data. Main sections of the chip are the program controller, data ALU, *x* and *y* memories, and interface connections. Its dual-memory configuration simplifies addressing *x* and *y* data for graphics, data and coefficients for transformations and filtering, and real and imaginary numbers for arithmetic functions.

Needless to say, this chip is powerful. Motorola provides two examples: It can do real-time stereo, 10 bands per channel (20 bands total), graphic equalization processing 88,200 16-bit samples per second via port C; and in about 3.5 milliseconds, it can do a 1024-point complex fast Fourier transform. Many approaches are possible with these chips. Some companies use a host processor just to interface with the user while the DSP crunches data. Others use the DSPs as

preprocessors, passing filtered data on to the host processor and its applications software.

From Analog to Digital

Most musical sounds, voices, film, and video camera outputs occur in analog forms. But we need to get them into digital forms so we can turn the DSPs loose on them. Once the DSPs are finished, we must then transform these digital forms back to their analog representations for the sake of our ears and eyes. This process of converting data forms enables us to use DSPs, compact disks (CDs), and other digital schemes difficult or impossible in the analog world.

Fundamentally, when we convert an analog signal to a digital one, we sample, as often and with as much precision as possible, the signal in question. Let's take an audio waveform as an example. Figure 2a shows an analog waveform, figure 2b shows the waveform's amplitudes being measured at discrete intervals, and figure 2c shows the resultant values stored as digital "samples" of the original. If the sampling is too coarse (i.e., too infrequent) or if the amplitude sensitivity is not available in sufficiently small gradations, the digital representation of the waveform will suffer.

Nyquist's theorem states that sampling must occur at twice the frequency of the highest waveform present to maintain desirable fidelity. The typical CD takes samples using 16-bit resolution at 44.1 kHz, which is more than twice the upper limit of human hearing.

—Gene Smarte
Special Projects Editor

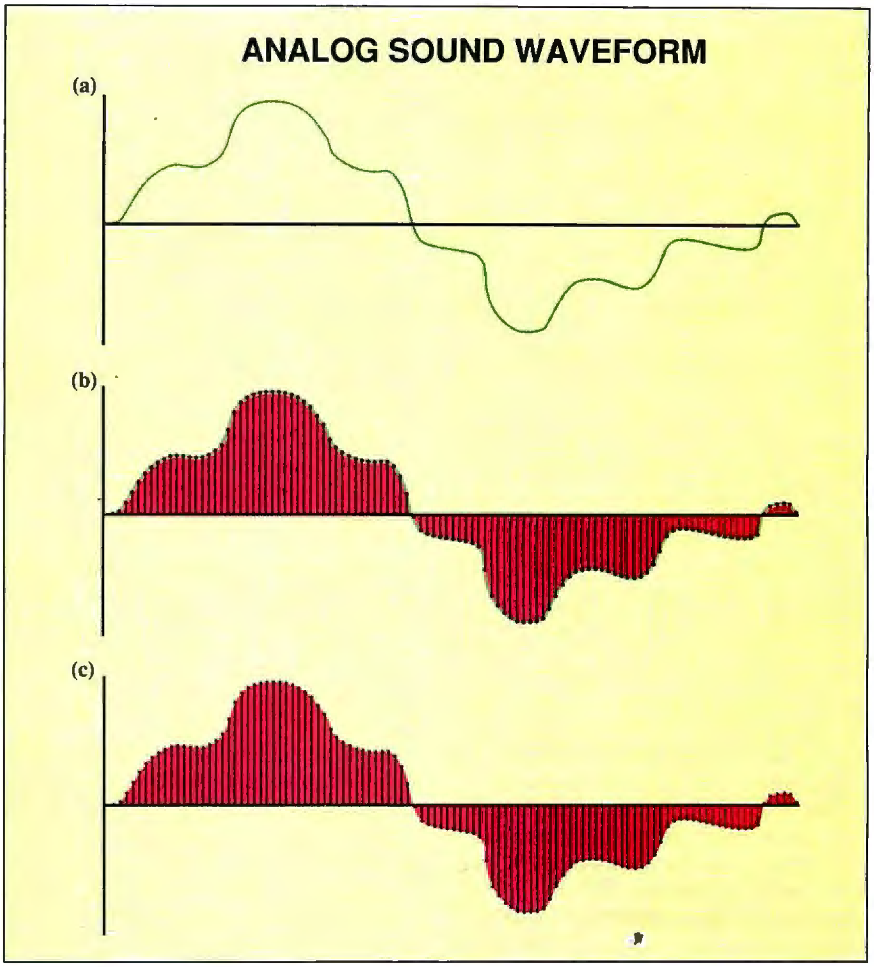

Figure 2: **(a)** *Original sample waveform;* **(b)** *waveform with lines indicating samples taken at specific times and at specific amplitudes;* **(c)** *waveform reconstructed using digital samples from* **(b)**. *How often and precisely the samples are taken affects waveform fidelity.*

Sounds

Be it voice recognition or music synthesis, sound processing has joined the ranks of microcomputer applications

Gene Smarte

Whether it is produced by a violin, an electronic keyboard, a human voice, a rocket motor, or a tree falling in the woods, sound for us is something we hear. For this discussion, let's define it as the transmission of mechanical energy through the air to our ears via vibrating waves of air. The human ear can usually detect frequencies in the 20- to 20,000-Hz (cycles per second) range.

Most sounds that we hear consist of some fundamental frequency, along with harmonics (multiples of the fundamental frequency) that give that sound its identifiable characteristics. If you've ever listened to the pure sound of a sine wave from an audio oscillator (see figure 1a), then you have a good idea of what tone without harmonics sounds like. It's

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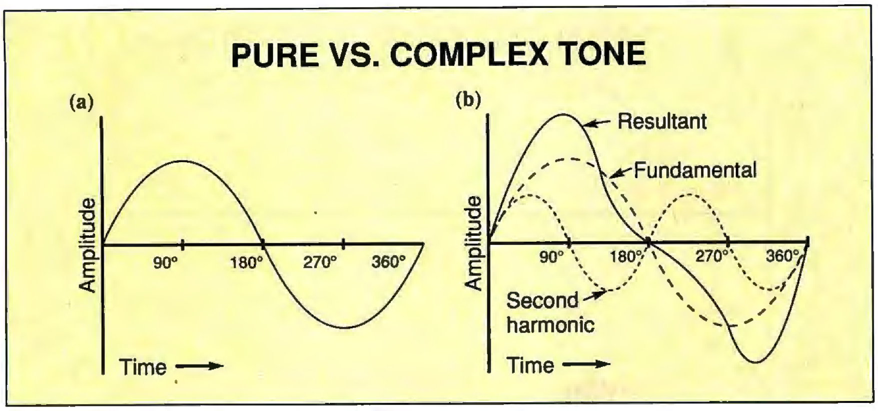

Figure 1: (a) *A pure sine-wave tone. This is a graphical representation of the sound produced by an audio oscillator.* **(b)** *A complex waveform is more common and includes the harmonics that give a sound its distinctive characteristics.*

primarily harmonics that make a flute sound different from a violin.

But the "pure" sound of a sine wave is rare. Much more often, sound is the result of many different waveforms in combination. The simple example in figure 1b shows a fundamental tone, its second harmonic (twice the fundamental), and the resultant waveform that we hear.

Most sound is much more complex, with many harmonics, subharmonics, and noise, compounded by attack, sustain, and decay curves. For an example, compare the start, middle, and end of a certain note on a violin with the sound produced by a xylophone sounding the same note.

For human voices, our vibrating vocal cords produce the primary sounds, excited by air driven past them. The sizes, shapes, and consistencies of our bodies, especially in chest, neck, and head, help make voices unique by reinforcing some frequencies and diminishing others. Add the manipulation of the throat, tongue, uvula, and cheeks, and there is little chance for two voices to be identical.

It's impossible to cover all the subtleties of sound in this article. But it's important to realize that sound processing can be very complicated. Imagine the tonal complexity of a single musical instrument—a violin, for example. Its fundamental sound, created by dragging many bow hairs across one violin string, is in itself complex. Add to that the resonances of the wood, the air within the violin, and the pressure that the violinist exerts.

Waveform analysis of the resultant tone would show a complex makeup. And each violin (or trumpet, or saxophone) is unique. Now, combine all the instruments of a symphony orchestra with the resonances of an auditorium. A detailed analysis of the sound would be quite an undertaking, yet our human ears can usually pick out and follow specific sections and sometimes even individual instruments.

Voice

Years ago, companies in the voice-and-computer business used to declare regularly how we'd soon have voice-activated systems on every desk. But, like fingerprints, human voices are as individual as the bodies in which they reside, and the all-encompassing voice-actuated systems haven't kept up with the promises. The computing power needed to produce these systems is just starting to arrive. In the meantime, we'll be seeing more specialized systems for narrower applications.

Current voice-recognition experimentation encompasses four areas: speaker dependence versus speaker independence, and continuous speech versus discrete speech. Speaker dependence usually confines a system to use by one person at a time. The system is trained to respond to a single person's voice characteristics. Naturally, this limits the general-purpose nature of a system, but it can be perfectly acceptable in many situations. Speaker-independent systems are much more complicated because you need considerably more analysis of the spoken word to identify a word from a variety of users' voices.

Discrete speech (i.e., words spoken with definite pauses between each one) makes the computer's job easier but burdens the speaker. Continuous speech, like that used in everyday conversation, fits in with how humans interact but plays havoc with the computer system trying to sort out the words.

In a panel discussion at SpeechTech '89 last May in New York, Ray Kurzweil of Kurzweil Applied Intelligence (Waltham, MA) said that for his company, true speaker-independent systems might be just around the corner. Kurzweil claimed that the company's prototype systems worked beyond expectations and, while not as good as the best "trainer" systems, were better than the worst trainer systems. Kurzweil also said that processing power in the hundreds or possibly thousands of millions of instructions per second is needed to achieve continuous speech recognition. Panelist Jim Baker of Dragon Systems (Newton, MA) agreed that a tenfold increase in computing power is required for continuous speech. As you might expect, speaker-independent, continuous-speech recognition is the pot of gold at the end of the voice rainbow. And right now, the technology is just not here.

But systems with 80386s (and, shortly, 80486s) along with lots of memory, digital signal processor (DSP) boards, and experimentation with neural networks are bringing voice-recognition goals closer. Dragon Systems' speaker-independent DragonDictate includes 16,000 words and can take another 16,000. This $9000 discrete-speech system includes a speech board, software, a microphone, an on-line dictionary, and documentation. System requirements are a 20- to 25-MHz AT-compatible computer, 0.5 to 1 megabyte of expanded RAM, 5 or more megabytes of extended memory, and Quarterdeck's QEMM-386 memory management software.

For continuous-speech systems, limited vocabulary approaches are more common. For example, a very popular niche application is digit recognition, because about 35 percent of American households still have rotary phones. Voice Processing Corp. (Cambridge, MA) offers an 80386-based AT-bus board, a Texas Instruments TMS320C25 DSP, and 1 megabyte of RAM for $5500. The company says that the system will have the ability to recognize "yes," "no," and the numbers 0 through 9 over a telephone line.

Future Speak

Alex Rudnicky, a research associate at Carnegie Mellon University's Speech Group (Pittsburgh, PA) confirmed that processing power is a big factor. Currently, researchers at Carnegie Mellon are using the NeXT Computer and Sun and Apollo workstations as they work toward a speaker-independent, continuous-speech system that will enable near-normal speech interaction with a com-

puter. The problem to be solved will become the user's focus rather than the interface.

While Rudnicky believes that a version of Star Trek–type voice communication with a computer is three to five years away, the researchers have made progress. They have a spreadsheet application in which any user can use continuous speech rather than a keyboard or mouse. For example, instead of typing in an equation, you would say, "Let cell c1 equal cell a2 plus cell b3."

Music

Starting with the first Apple computers' squeaks and squawks, we've seen an evolution of sound capability through the Atari, Amiga, IBM PC, Mac II, and

A version of Star Trek–type voice communication with a computer may be three to five years away.

other systems. Coupled with the emergence and public acceptance of the compact disk (CD) standard for sound sampling and reproduction, we can now do more and more sound manipulation with personal computers.

The methodology of producing electronic music has changed a lot over the years. Synthetic music started with analog systems, using oscillators and modifiers cascaded to approximate the sounds of genuine instruments. Further experimentation yielded the "additive" approach: Many discrete oscillators generate harmonic frequencies separately, and then these outputs are added together to greatly improve the realism of the synthesized sound. While more accurate, additive synthesis has the disadvantages of being slow because of all the computation and control circuitry required, and more costly as well.

A whole new approach surfaced when an FM technique invented by John Chowning of Stanford University used one oscillator modulating another to produce realistic sound quality with less work. This FM technique became popular and attractive to synthesizer manufacturers looking to reduce complexity and increase performance. Other proprietary approaches, as well as combinations and variations on tried-and-true techniques, also exist.

MIDI

One of the most powerful and exciting things to develop in the music world during the last few years is MIDI. This standard for hardware and software musical information interchange was originally adopted by the electronic music industry in 1983 and has undergone several enhancements as the users and available equipment have become more sophisticated. Basically, it enables many different brands and types of music-related equipment to communicate effectively, much as telecommunications protocols facilitate networking.

MIDI-equipped keyboards, drum synthesizers, personal computers with MIDI add-in boards, recording equipment, and composition and sequencing software share digital data that specifies timing, instrument type, note (frequency), expression, and other related information at 31,250 bps via a common cabling system.

You can also set up a master-to-slave relationship among equipment so you can play, for example, a saxophone note on one machine and have another machine duplicate the note in, for instance, a violin sound. MIDI controllers for guitars and wind instruments are now available, enabling artists in one area to transpose some of their skills and creativity to other "foreign" instruments, with mixed success.

Tom Beckman, president of Roland-Corp (Los Angeles, CA; a company that manufactures electronic music products), said that although there are several commercial DSPs designed for sound manipulation, most electronic-instrument makers use proprietary chips because each company has some variation or specialty that it wishes to herald. Manufacturers often use different techniques across their lines of products to adjust the cost-to-performance equations, using lower fidelity, less complicated synthesized sounds in less expensive equipment, and sampling sounds for their top-of-the-line products as faithfully as possible, under conditions that are as ideal as possible.

At first glance, you might assume that sampling and digitizing a bona fide instrument such as a Steinway grand piano for use in electronic keyboards can't be improved upon. After all, sampling and

continued

playing back at a CD rate can yield excellent fidelity.

The problem is that when the Steinway sound is sampled, however faithfully, it is sampled under specific conditions. The human pianist strikes a key at a certain speed and with a certain velocity. That specific piano under those specific conditions is recorded and appears whenever the electronic Steinway is played. The electronic piano loses much of the mechanical piano's expression capability despite the keyboard sophistication and software of some synthesizers that let you manipulate the sampled sounds.

Beckman concluded that the future of electronic music holds a great deal of promise. Roland is experimenting with voice recognition for possible use by musicians as they perform. Instead of typing commands, flipping switches, or swapping disks, a spoken command would initiate a predetermined series of events to prepare the electronics for the next setup.

One problem does come to mind: Suppose the performer's command word is contained in lyrics to a song. The first time the word is sung, the bank of electronics would switch to an entirely new setup with disastrous results. The old adage of choosing your words carefully would have special meaning here.

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Images

Microprocessor-based image processing reduces system cost, but how do you improve performance?

Walt Penney

Digital image processing concerns the input, enhancement, statistical analysis, and output of gray-scale and color-image data. Such data is generated by the sensing of a real-world object, whether it be a scanned image of an x-ray or an image of Neptune transmitted by the Voyager satellite. In a typical application, the objects of images actually exist; the sensing of the image object creates the image data. (For an example of the difference image processing can make in an image, see photo 1.)

Images are typically two-dimensional representations of objects—essentially a digital photograph. (There are imaging applications, such as volumetric reconstruction of magnetic resonance imaging [MRI] data, where image data is three-dimensional, but you can consider a two-dimensional image to be a cut or slice across such an image.)

Image-processing functions operate on the individual pixels (or data elements) of the image data array. In contrast, in the field of rendering as applied to CAD, mechanical engineering, and other applications, a set of drawing commands and attributes generates the image data. In other words, digital imaging functions can operate directly on raster image data, while CAD or draw-type functions render a synthetic raster image from an image description.

Unique Characteristics

Digital images tend to be very large. Unlike CAD drawings or desktop-publishing pages, where data can be represented as a display list, as a metafile, or in a page-description language, images can only be described by their pixel data. At 8 bits per pixel (256 shades of gray—a standard pixel resolution), a 1024-by-1024-pixel image takes 1 megabyte of storage. A true color image (24 bits per pixel—8 bits each of red, green, and blue) of the same size requires 3 megabytes of storage.

One key to improving image-processing performance is the availability of high-bandwidth pathways to move image data between processing components. In a typical scenario, image data resident in a frame buffer is moved into host memory for processing and then moved back into the frame buffer for display. The speed of this transfer may have a greater effect on perceived operational performance than on the actual speed of the imaging operation itself.

Image-processing functions tend to fall into two categories: *point* and *neighborhood* operations. Point operators perform on individual image-pixel data, while neighborhood operators work on connected groups of pixels. In either case, applying an operation to an image or a region of interest of an image involves executing the same function repeatedly for each pixel involved.

This type of processing lends itself well to three different approaches for improving performance. First, optimizing the lowest-level processing routines, which are called repeatedly on a pixel-by-pixel basis, will significantly boost processing speed. Second, special-purpose accelerators that perform a few

continued

functions very fast can generate near-real-time performance. And third, parallel-processing techniques, where multiple processors act independently but in parallel on strips of image data, work well for imaging functions. (Various hardware possibilities for improving performance are discussed in the text box "Hardware Solutions" on page 252.)

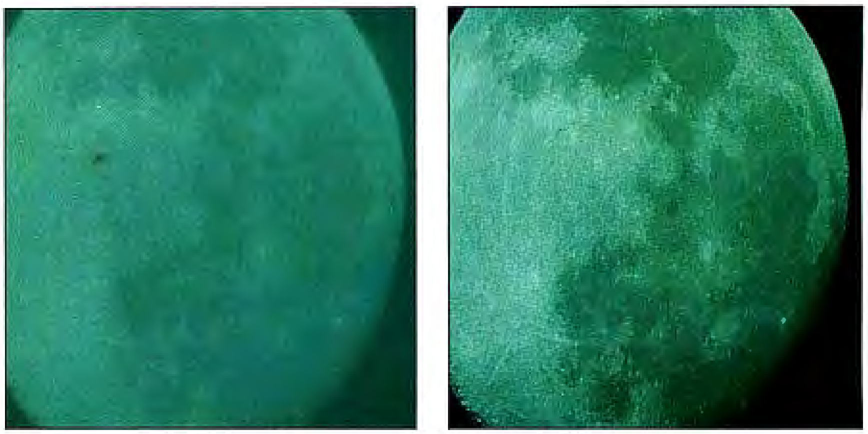

Photo 1: *Improvements wrought by image processing. Left: An original image of the moon at 512- by 480-pixel (8 bits per pixel) resolution, shot through a telescope. Right: The result of processing the image by first performing a histogram equalization, remapping the equalized data to frame-buffer memory through the generated lookup table, and performing a 3- by 3-pixel high-pass convolution on the entire image.*

Input, Process, Output

The input phase consists of bringing image data into the image-processing system. Input sources include video digitization, an optical scanner, other digital-sensor output (such as LANDSAT data), the output of an image rendering, or image data residing in a file. You can also use nonimage data (such as object attributes) as inputs into the system to identify objects within an image through pattern matching.

The processing phase assumes that image data resides within a frame buffer. A frame buffer is typically coupled with a video display processor, but you can also have a virtual frame buffer, which exists in memory independently of a display. The virtual concept becomes very important when managing images larger than standard displays. (Various software possibilities for improving performance are discussed in the text box "Software Solutions" on page 254.)

The output of an image-processing function can be the image data itself. The output can be solely the display of the image, saving the image data to a file, or generating a hard copy of the image using a printer or film recorder.

continued

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Hardware Solutions

Host CPU

The simplest approach to image processing is one in which the host CPU performs all the imaging functions. You can use the standard system video display memory or a secondary display adapter as the imaging frame buffer.

In a single-tasking environment such as DOS, system performance is determined solely by CPU performance, bus bandwidth, and frame-buffer interface. Under a multitasking operating system such as Unix, task loading and available system memory also affect performance.

Historically, this approach has offered minimally acceptable performance at the lowest cost. However, with 80386- and RISC-based workstations and buses capable of running at 33 MHz, this solution is more viable.

Application Accelerators

Application accelerators can speed up many different processing tasks, including image processing. The accelerator is usually an add-in board that provides hardware assistance for certain functions. Accelerators typically employ one of two approaches: dedicated logic or general purpose.

The dedicated-logic approach involves placing application-specific ICs, digital signal processors (DSPs), proprietary logic, or some combination of technology on the accelerator board. The board is capable of executing a limited set of functions that cannot be modified or expanded without changing the hardware. Dedicated-logic accelerator boards that use off-the-shelf chips cost around $500; more sophisticated accelerators can range from $5000 to $12,000.

Dedicated accelerators generally process only regions of interest that are rectangular. They may even restrict the granularity of a rectangular ROI to 16-pixel horizontal boundaries. The applications software must decide whether the accelerator can process the source ROI and, if not, perform the function using the host CPU, resulting in tremendous performance differences between processing rectangular and irregular-image ROIs.

It often takes longer to transfer the image data to be processed to and from the accelerator than it does to do the actual processing. A high-speed interface between the frame buffer and the accelerator greatly enhances performance. Several manufacturers have adopted the DT Connect bus protocol from Data Translation (Marlborough, MA), including Mercury Computer Systems (Lowell, MA) and Toshiba (Irvine, CA), while other manufacturers, such as IBM, use proprietary buses for such interconnections.

As an example, the operations in table A (the results are shown in photo 1, right, in the main text) were performed using a DT2851 frame buffer, first alone and then in conjunction with the DT2858 coprocessor, which is connected via DT Connect. The test was performed on both a 6-MHz IBM AT and a 20-MHz Everex Step 386.

The alternative accelerator approach is to use a general-purpose CPU dedicated to imaging. This CPU, along with local code and processing memory, can reside on a separate accelerator board; some current implementations use the 80860 chip from Intel. Or, the CPU can be integrated onto the frame buffer itself, as is typically done with Texas Instruments' TMS34010.

General-purpose CPUs are a double-edged sword for imaging solutions. While they provide a flexible, expandable path for function growth, they require a great deal of chip-level software. Software developers, even those in the driver business, are loath to make such a software investment in nonmainstream-CPU chip-level code. To circumvent this problem, chip manufacturers provide C cross-compilers, but the compiler output often doesn't match the chip's performance capabilities, sometimes to the extent of negating the effect of the chip altogether.

The capabilities of a general-purpose CPU accelerator are completely dependent on the software. As a rule, the more processing done at the chip level, the higher performance the system will yield. An initial implementation might have a limited set of chip-resident imaging functions, while future software versions would transfer more of that capability to the chip itself.

Feedback Lookup Tables

Feedback lookup tables provide a low-cost solution for some applications that require real-time processing of acquired video image data. You can perform any logical or arithmetic operation by passing source image data through a transformation or LUT, provided that the size of the LUT matches the range of image data. In other words, if the source image data is 8 bits per pixel (the range is from 0 to 255), a 256-entry LUT will suffice.

To add the value 10 to each pixel, simply set the value at LUT location m to $m+10$. To combine each pixel value with the value n using the AND operator, set the value at LUT location m to m AND n. Some implementations also support an input multiplexer, which will combine video input image data with frame-buffer data, generating deeper (more bits per pixel) image data.

By passing this type of data through an equally deep LUT, you can perform arithmetic and logical operations between the source image and the incoming video. By appropriately scaling the two image sources, real-time frame averaging can be supported. Finally, you can use pan and scroll registers to offset image data in the x and y directions during the feedback process. This can be used to accomplish neighborhood operations such as convolutions.

While a clever solution, feedback LUTs present the problem of data clipping. Data output from the LUT transformation may exceed the data bandwidth (in the example above, what will happen to input data values 246 to 255 when added to 10?) and is usually clipped to maximum or minimum values (in this case, 255). This loss of accuracy is compounded with repeated passes through the feedback loop with the same image data—the results of neighborhood operations performed through feedback LUTs may not be accurate.

Parallel Processing

Parallel processing is really an extension of the application accelerator technology. By providing multiple identical processing paths, whether you are using dedicated-logic or general-purpose CPUs, the improved processing times will approach the inverse of the number of processors.

The applications software must take the ROI of the image data to be processed, divide it into equal strips, and feed these strips into the processing engine. Better yet, the processor logic it-

Table A: *Notice the difference an accelerator can make in image-processing performance. Also notice the difference the faster computer makes when the host CPU does all the processing (the DT2851 alone). The 2858 coprocessor performed all three of the listed functions when it was present; when it wasn't, the host CPU performed all three. (All times are in seconds.)*

IMAGE PROCESSING TIMES

	Histogram equalization	Remap data	3 by 3 high-pass convolution
6-MHz AT			
DT2851	20	16	65
DT2851/2858	2	1	3
Everex Step 386/20			
DT2851	5	5	14
DT2851/2858	<1	<1	2

self could manage the division and routing of image data to all its processors.

Parallel processing of image data differs from rendering graphical images in parallel. Image data takes the same amount of time to process regardless of the source data values; rendering complex objects takes much longer than rendering backgrounds. Decisions as to how to divide image data for parallel processing are much simpler, based solely on size.

While parallel processing is in widespread use for graphics rendering, this is still an emerging technology for image processing.

Pipeline Processing

Another approach to image processing is to couple multiple processing elements together in a hardware processing pipeline. In such an architecture, image data moves through various components or physical boards, each of which can perform a set of functions on the image data. The data throughput rate is very high, typically at or near video speeds, so an image can traverse the entire processing pipeline in one frame time (one-thirtieth of a second). In such a system, the type of boards and the order in which they are installed can completely determine the pipeline's performance.

The pipeline architecture differs from the feedback LUT approach in that full 16-bit data paths are supported for 8-bit source image data, including a 16-bit-wide accumulator frame buffer. In this way, processed data is preserved at full accuracy, while the user manages clipping at the end of the process.

At the heart of most imaging pipelines is an ALU. The ALU supports arithmetic and logical operations between image data and a constant or between two input images, usually one operation each (arithmetic and logical) in the pipeline, and sometimes several in a series.

Off-Screen Video Memory

An image-processing architecture can have multiple megabytes of video memory on the frame buffer (or make the addition of more frame-buffer memory an option), of which only one frame page can actually be displayed. The off-screen memory can be used to store multiple images to speed up operations between two images or to store images larger than the display to provide quick pan and scroll functions.

This memory can also be used to store many smaller images that make up an image sequence (these images are typically smaller than the frame display). By zooming the display to make the image full-screen, and quickly panning and scrolling around the image data, you can create the effect of the image source in motion, much like flipping the pages of a kinetoscope.

To be useful, either the host CPU or a dedicated controller or processor board (if one is present) must be able to access this memory directly. Otherwise, it has no advantage over standard system memory.

Software Solutions

Virtual Frame Buffer

The virtual frame buffer separates the processing functions from the physical display in software. This removes several of the limitations that the display hardware imposes, such as different output lookup tables (LUTs) for multiple displayed images, handling images larger than the display, and managing multiple images of different sizes.

In such an implementation, all image data is maintained and processed in memory—this can be virtual memory when dealing with Unix workstations. The display process is handled independently of the image processing and consists of transferring image data from the virtual frame buffer in memory to a window on the display. During this transfer process, the data itself can be transformed to manage zoom, pan, scroll, and LUT functions.

Graphical User Interface

The trend at both the personal computer and workstation level is toward a graphical user interface. Since image processing is presented either as a standalone application or as an integrated part of another application, it must conform to such GUI standards.

Using the host CPU and frame buffer for processing makes this task easier because the GUI tools are already in place. The virtual frame buffer also fits in nicely, because the display process, being separate from the image processing, can be routed through the GUI.

Problems arise when dealing with dedicated imaging subsystems independently of the host display, as the standard GUI tools are generally not available. In such cases, you can use two monitors, with control and status enabled through the GUI on the system display and image data displayed on the subsystem.

Imaging Tools and Applications

The typical image-processing solution supplier wants two levels of software support—an end-user application that provides a set of standard imaging functions in an easy-to-use package, and a comprehensive set of imaging routines that allow the use of additional algorithms.

General-purpose imaging software can often become tuned to a specific vertical market by adding market-related functions. Imaging software tools can provide a wider range of options for the value-added reseller and system integrator.

System Solution Approaches

The initial decision for an imaging solution supplier is what to use as the delivery platform, including both the physical host computer and the operating system. While microcomputers provide the lowest-cost solution (and with application accelerators, they can provide high performance), imaging applications under DOS don't coexist well with networks; they function best as standalone nodes. Because networking is built into the workstation environment, workstations tend to provide a better framework for workgroup management and processing of image data.

In years past, high-end imaging solutions consisted primarily of proprietary, stand-alone hardware-and-software boxes. The general state of the art in computer technology dictated this approach; for many real-time applications, it is still the only valid approach. The trend today is away from dedicated imaging subsystems and toward accelerators and software that can be integrated into standard personal computer and workstation platforms.

Another approach is to use device-independent software that can run across a wide variety of hosts and imaging products. Software such as Image-Pro from Media Cybernetics (Silver Spring, MD) is both device-independent and device-intelligent; that is, it will use whatever capabilities are available in the imaging hardware. This allows the systems integrator to select the best hardware that is available for the application, knowing that adding an accelerator will automatically provide an increase in the system performance that the software can handle.

One of the pitfalls in image processing is that new hardware is being developed faster than software support. This is particularly acute in the area of accelerators. Many accelerator manufacturers are working on developing a standardized software interface that will provide a migration path to new hardware while still maintaining compatibility with existing software. Device-independent software can provide a hedge against technical obsolescence.

Nonimage data, such as histogram counts, image statistics, and object information, can also be output from an imaging system.

A Typical System

A typical image-processing workstation has a host computer with some or all of the following components: a frame buffer, a display monitor, a video digitizer, a video source, and an application accelerator (see figure 1).

A frame buffer consists of high-speed video memory coupled with a video display system. It may contain more memory than it needs for a single display; it can use the additional memory for code and data storage or multiple display pages, or to hold a single large image. The video display system usually consists of output lookup tables (LUTs) for assigning actual colors or gray scales to image-data values, and D/A converters for converting digital image data into an analog video signal for display.

The system usually gains access to the frame buffer in one of two ways: either through a single byte, word, or command interface, or by the host computer accessing the frame-buffer memory directly. Memory-mapped frame buffers mean better performance for systems that rely on the host computer for processing, since it can operate directly on frame-buffer memory. Otherwise, the system must transfer image data from the frame buffer to local memory for host processing and then back again for display.

The characteristics of the display monitor must match the display requirements of the frame buffer. A standard National Television System Committee (NTSC) signal (defined as 512 by 480 pixels interlaced) requires a 15.75-kHz monitor, while a 1280- by 1024-pixel noninterlaced signal requires a 64-kHz monitor. The physical measurements of the monitor have no direct bearing on the input video signal.

Input video can come from an analog video signal generated by a camera or VCR source as an NTSC or RGB signal (at 480 lines) in real time (30 frames per second). Alternatively, video can be input from a variable scan source (higher resolution or slower frame-rate video

continued

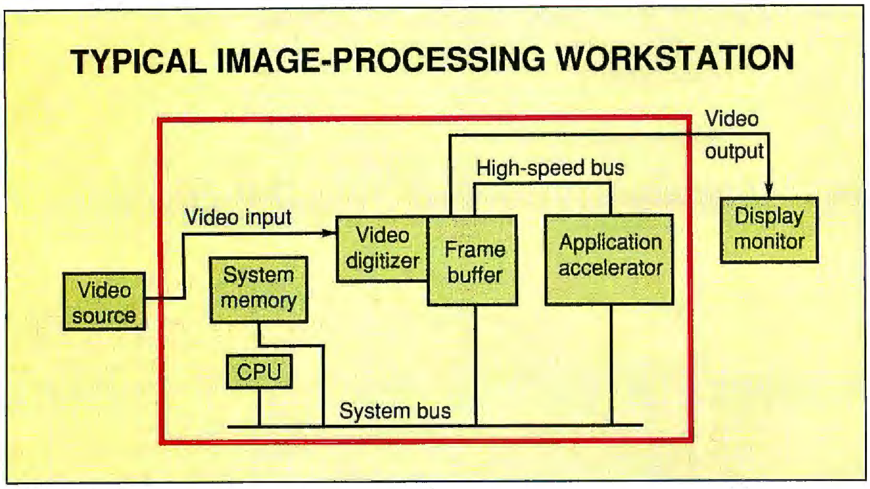

Figure 1: *Some imaging workstations will contain only some of the additional image-processing components, while others will have all of them, as this one does.*

sources). This analog data is converted, or digitized, via an A/D converter and is placed in the frame buffer. (Video digitizers for the European market have to handle phase-alternate-line input.)

Optical scanning can also be used to generate image data. In this case, a sensor array, typically at 200, 300, or 400 dots per inch, generates digital scan-line output as it moves past a flat source. The paper can move over the sensor, the sensor can move over a fixed piece of paper, or both the sensor and the paper can be stationary while the internal optics move. These scan lines are recomposed as the image data in the frame buffer.

An application accelerator is an add-on hardware card or subsystem that has its own processing capability, independent of the host CPU. As the name implies, the function is to accelerate the processing of the imaging application.

Real-World Applications

The medical field has many uses for image processing, including processing and analyzing MRI, sonograms, x-rays, and CAT scans. Often, the output of devices is direct digital information; when it isn't, a film recording of the image is scanned or digitized. In medical research, the image from a microscope can be fed into an imaging system or stored on a videotape for later processing.

Medical applications typically generate high-resolution images of at least 1024 by 1024 pixels. An accurate analysis of image data often requires pixel accuracy to at least 12 bits, even though only 8 bits can be displayed. Performance is usually critical in medical applications; the imaging workstation is a small and relatively inexpensive component of the diagnostic equipment and shouldn't be a throughput bottleneck.

When photo interpreters use image processing, source image data is often aerial photographs shot during reconnaisance flights. These photographs are digitized at the highest resolution possible, in the 4096- by 4096-pixel range. Although perhaps only viewing a small piece of the image at a time, the photo interpreter needs the ability to smoothly pan and scroll around the entire image.

In publishing, image data can be two-tone, gray-scale, or color. Images are typically not very large, and the primary concern is usually improving the look of the image. As you move from the desktop publisher to the quick printer to the commercial publisher, the complexity of the imaging system varies correspondingly.

Image processing is used in commercial and industrial applications involving nondestructive testing. A record of an event—the movement of a tire through water, the inspection of the inside of a jet engine, the flow of paint droplets from a sprayer—is captured on videotape. This tape is later played back through the imaging system, and each frame is analyzed and processed. Since the input medium is video, these systems require 480-line imaging frame buffers and displays.

In another class of inspection applications, the analysis of video image data is done on the spot without the intermediate step of capturing to videotape. In such assembly-line-type applications, the video data must be processed in real time using dedicated hardware.

LANDSAT and other satellites orbiting the earth generate remote-sensing image data. This data is multispectral; that is, it contains bands of information digitized at frequencies outside the visible spectrum (such as infrared and near-infrared). The images generated are very large (again in the 4096- by 4096-pixel range) and require an imaging system that can manage multiple bands of connected large images.

One of the fastest growing applications for image processing is document management and automation. Such systems usually consist of a high-capacity optical scanner with optical character-recognition capabilities, which generates black-and-white image data. A standard 8½- by 11-inch page scanned at 300 dpi generates 1 megabyte of image data.

Traditional processing requirements are small, but image compression and decompression are important. Systems that archive data and rarely access it give a higher priority to compression speeds; those that archive data once but retrieve it many times for review and editing must have an optimized decompression mechanism. Accelerators are often used for compression and decompression.

Imaging Tomorrow

As the processing power of standard 80386 and RISC-based workstations increases and as high-resolution display technology becomes standard, software is all you will need to turn a general-purpose computer into an image-processing workstation. As imaging becomes more integrated into other technologies, such as document management, imaging applications will have to coexist and communicate with database applications and function across network connections.

Both dedicated-logic and general-purpose CPU accelerators will continue to flourish. Dedicated-logic solutions tend to be less expensive and reach the marketplace more quickly, but they also become outdated more quickly. In the long term, the general-purpose CPU is likely to win out. Texas Instruments is currently pursuing this strategy by following the 34010 with the 34020, which is downwardly software-compatible but yields at least a fourfold speed improvement.

Finally, color will become a requirement for imaging applications. As the possibilities of color become more well known, as vendors become more adept at managing color image data, and as hardware technology specifically for color is developed, color will replace gray scale as the accepted medium for many image-processing applications. ■

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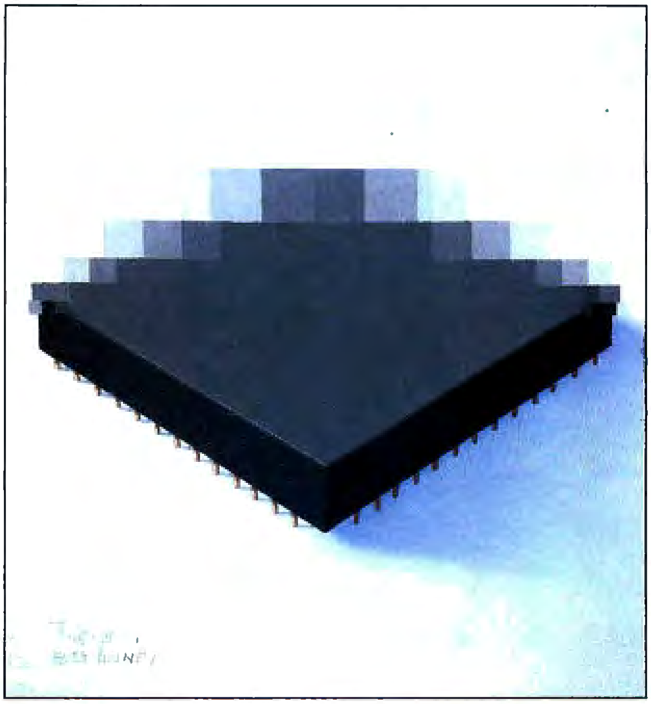

The Three Steps

The three hierarchical steps of signal processing are preprocessing, feature extraction, and pattern recognition. Currently, the most widely used application is preprocessing. This group of operations deals mainly with the quality and correctness of the signals. In speech and audio applications, preprocessing includes (but is not limited to) preamplification, equalization, and noise reduction, most of which you can accomplish with digital filters.

In image applications, preprocessing takes a more complex form. It includes such techniques as intensity and geometric correction, as well as geometric transformation. These techniques require using both digital filters and computations like matrix multiplication and inversion.

In many applications, once the input signal (sound or image) has been preprocessed, the task is considered to be complete. For instance, in the digital recording of a CD, the signals from both the left and right channels are digitized using A/D converters at a sampling rate of 44.1 kHz (the Nyquist frequency for the 20-kHz audio range). The signals are then encoded digitally using error-detection and -correction schemes and modulated so they can be written to a master laser disk. The end result is a superb sound recorded on a laser disk (preprocessing is complete).

Developers can achieve a higher level of processing if they incorporate DSPs into the next generation of computer systems. By adding high-performance floating-point DSPs to existing computers, the average user could have access to features like a voice-activated man-to-machine interface.

A current topic of interest in which intense research and development are under way is pattern recognition, with applications in voice-activated workstations, autonomous vehicles, and factory automation.

To perform any sort of pattern recognition, you first need to extract certain

continued

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features or parameters from the preprocessed signal. In speech processing, attributes such as formant frequencies, pitch, and spectra provide for a sufficient and accurate representation of a speaker's voice. Fourier descriptors and invariant moments, on the other hand, are the parameters used in describing an object within an image.

The parameters obtained from feature extraction are collectively used to identify speakers or objects by comparing them against stored reference features. Based on possible similarities or differences and an acceptance criterion (a threshold), the system decides on the identity of the speaker or object.

Building DSPs

DSPs, until now, have been implemented using one of the following platforms: generic building blocks, function-specific building blocks, and RISC-like general-purpose DSPs. However, a new approach using application-specific ICs (ASICs) customizes the DSPs.

The first platform, generic building blocks, includes implementations like conventional complex-instruction-set-computer microprocessors and bit-slice processors. CISCs, accompanied by math coprocessors, are the most flexible and readily available platform, but this flexibility comes at an often-unacceptable price in speed performance. CISCs also lack the additional functionality that is needed, such as bit-reversed addressing for fast Fourier transforms (FFTs) and circular addressing for time-domain convolution. Bit-slice processors can be fast, but the necessary microcoding is expensive—in time and money. Moreover, bit-slice processors require the use of multiple devices, such as address sequencers, ALUs, multipliers, registers, and memory, thus reducing the amount of available board space.

The second platform, function-specific building blocks, uses VLSI devices designed for DSP tasks such as 1024-point FFT, 3×3 image convolution, and 64-point correlators. Perhaps the fastest platform for tasks with clearly defined inputs, function-specific building blocks are also known as VLSI distributed processing (each device in the system is responsible for only one task). Such a system can be costly and lack flexibility in architecture and algorithm design.

The third platform uses RISC-like general-purpose DSPs, which have evolved rapidly since their introduction about 10 years ago. Software development with this platform is comparatively easy, and internal architectures dedicated to number crunching, together with a robust DSP-oriented command set, provide better overall performance.

In certain applications, general-purpose DSPs will not perform satisfactorily. You may need a set of specifications that is not embedded within a general-purpose DSP. For example, processing stereo-audio signals in a CD player entails using a special interface that allows for input and output of the right and left channels. This leads to the final and perhaps most advanced form of implementation, called ASIC design.

In ASIC design, you can customize the DSP architecture by optimizing the device for performance, reliability, board space, design security, and cost. Due to advances in micron and submicron CMOS technology, the ASIC DSP can accommodate peripheral functions, memory, random logic, and, eventually, more than one DSP on a single chip. Such

continued

Digital Filters

1-D FIR Filter

The following equation describes a one-dimensional finite impulse response (FIR) filter:

$$Y(n) = \sum_{k=0}^{N-1} h(k)\, X(n-k)$$

where $h(k)$ is the filter coefficients and $X(n)$ is the input data sequence.

FIR implementation is nonrecursive (see figure A) and is therefore always stable (i.e., it converges to a finite number). It exhibits a relatively low quantization error as a result of arithmetic operations and has no limit-cycle problem. FIR filters can independently achieve linear phase with no phase distortion.

Despite these features, FIR filters have deficiencies. They usually use too many multiplications (due to the many required coefficients) to generate a sharp cutoff frequency. Thus, they are suited to applications that need zero phase distortion and don't have too many multiplications. At one time, these filters used registers, multipliers, ALUs, and conventional CPUs.

Circular addressing is another feature that eliminates checking for upper and lower limits of the data structure and allows an incoming sequence $X(n)$ to be automatically inserted into data space. Consequently, very fast and memory-efficient FIR filters can be implemented.

1-D IIR Filter

The following equation describes an infinite-duration impulse response (IIR) filter:

$$Y(n) = \sum_{k=1}^{M} a_k Y(n-k) + \sum_{k=0}^{N} Sb_k X(n-k)$$

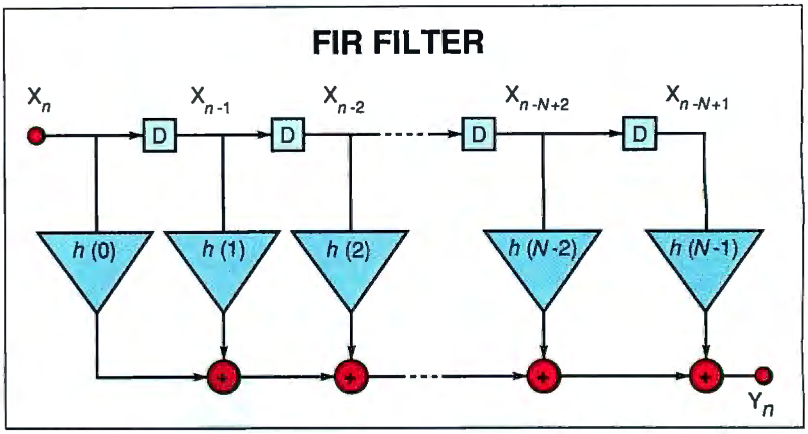


Figure A: *The fundamental format used to implement an FIR filter. FIR implementation is nonrecursive and is therefore always stable (i.e., it converges to a finite number). It can independently achieve linear phase with no phase distortion.*

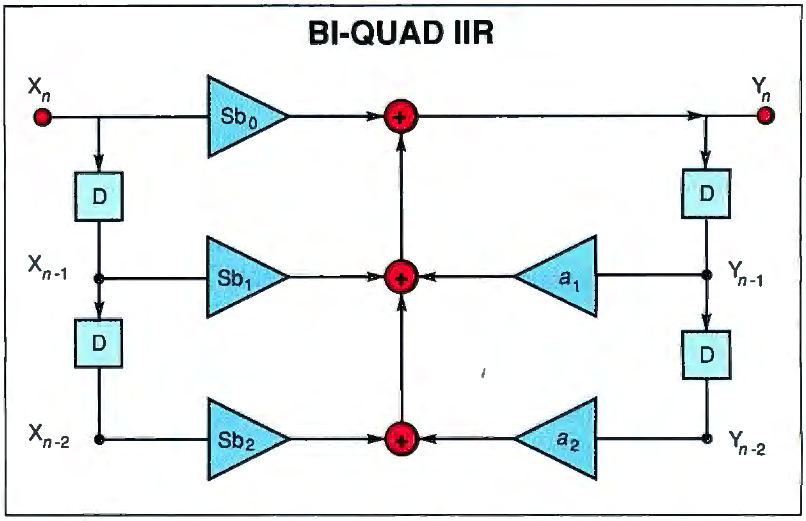


Figure B: *The most common method of implementing IIR filters. In digital-filter design using the IIR approach, you would use this format as the fundamental block (bi-quad realization). Therefore, most IIR implementations would use the cascaded second-order bi-quad filters.*

a high level of logic integration suits applications that are too complex for a general-purpose DSP. ASIC design could also reduce cost by providing a scaled-down DSP for applications where a general-purpose DSP is overqualified.

To date, several ASIC DSPs have been produced from different "core" macrocells (Type-1, Type-2, and Type-3). Each of the cores is a DSP consisting of four functional modules: arithmetic and logic, address calculation, program sequence and control, and internal memory (see figure 1). Since all modules communicate with standard signals, you can combine and modify the macros using standard interface signals. Internal programmable logic arrays in the program sequence and control block decode the program instructions, or microinstructions, and generate control signals. You can alter the instruction set by reprogramming the PLAs.

Each DSP core is optimized for a certain application area (see table 1). For example, a Type-2 core provides a special I/O interface to comply with the I²C serial-bus standard for digital-audio applications. The I²C bus structure lets you transmit commands, as well as data, through a serial interface that is useful in adaptive filtering applications. As a result, you can substantially reduce the number of components and the cost of the system, as well as increase the flexibility with which you can digitally filter audio signals. The Type-3 core has 16 first-in/first-out I/O registers and a 32-bit IEEE-754 floating-point data format for

IIR filters are typically designed from analog filters, since the techniques and procedures for analog-filter design are well developed and require fewer computations. Analog filters are converted to digital filters using impulse-invariant and bilinear transformation methods. Similar to analog filters, IIRs are preferably realized in a cascaded form of second-order filters (bi-quad IIR) for algorithmic simplicity and low sensitivity to coefficient quantization. (See figure B.)

Compared to FIR filters, IIR filters are more efficient in terms of memory requirements, number of multiplications, and filter response. Their transition band is relatively sharper, and fewer delay elements and multiplications are required. In addition, flexible address pointers and circular addressing mode make IIR design straightforward. However, distortion delay (nonlinear phase), instability, limit-cycle problems, and higher quantization error in arithmetic operations are all deficiencies of IIR filters.

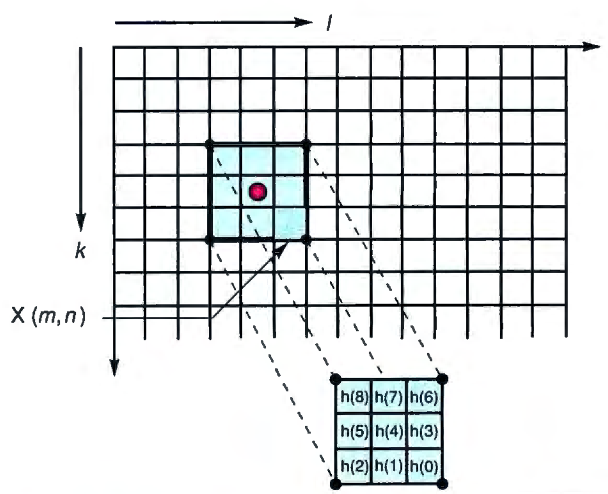


Figure C: *How the output Y*(m,n) *is computed according to the equation in the text. In practice, the center pixel (see the circle) of the 3×3 input image is computed instead of the corner pixel that the arrow points to. The indexes of the filter equation are adjusted accordingly.*

2-D Digital Filters

Similar to the one-dimensional case, two-dimensional digital filters consist of two classes: FIR and IIR. In image processing, where shapes and relative distances between objects are important, zero-phase and linear-phase FIR filters are commonly used.

FIR filters in two dimensions exhibit the following I/O relationship:

$$Y(m,n) = \sum_{k=0}^{M-1} \sum_{l=0}^{N-1} h(k,l)\, X(m-k,n-l)$$

where Y is the output of the filter, X is the input image, and h is the filter's impulse response. Generally, one-dimensional design techniques are used to compute the coefficients of a two-dimensional FIR filter. The most commonly used two-dimensional FIR filter is a 3×3 coefficient matrix, usually referred to as a 3×3 input mask. There are over 100 different input masks that have known coefficients to produce transfer functions for low-pass, high-pass, and noise-removal filters.

Figure C shows how output $Y(m,n)$ is computed according to the above equation. In practice, however, the center pixel (centered in figure C) of the 3×3 input image is computed instead of the corner pixel that the arrow points to. The indexes of the filter equation are adjusted accordingly.

Similar to one-dimensional FIR, the quantization error is small. If the input image is digitized to 8 bits (shades of gray) or 24 bits (RGB color) and the input-mask coefficients are generated in 8 bits, then you need to accumulate 32-bit products for image-processing applications where you need two-dimensional digital filtering.

DSPs need to perform a 3×3 image convolution over a large memory area. Because the intensity of each pixel is obtained in integer format, it would make the most sense to perform digital filtering using integer operations. A 24-bit integer format is more than sufficient for most typical image-filtering applications.

high-accuracy, high-speed, image-processing applications.

Perhaps one of the most attractive features of ASIC DSPs is that they are software-programmable. The ability to create different functions and tasks is essential in most designs, providing a great deal of flexibility when you need to execute a variety of application programs with a single device.

If you need to create programs for a new DSP, a "chip-definition file" conveys all the necessary information about memory size, data format, registers, and other device features to the assembler, the linker, the simulator, and, finally, the emulator. Applications that can use floating-point DSPs range from digital filtering (used in preprocessing), to rapid and optimized FFT calculation for feature extraction, to graphics and pattern recognition.

Digital Filters

Digital filters are programmable, reliable, repeatable implementations of a desired frequency response that is usually used to alter the frequency content of an input signal. A low-pass filter, for example, allows only the low-frequency components to pass.

Once the desired spectral characteristics are specified, a digital filter can achieve those specifications with ease, efficiency, and accuracy. Digital filters are implemented on DSPs through various structures (e.g., the finite impulse response and infinite-duration impulse

continued

response filters). (For more details about specific types of digital filters, see the text box "Digital Filters" on page 262.) With the emergence of powerful floating-point DSPs, realizing such structures is no longer the focal point of design. The important issue now is meeting the specific demands of the market, which may include attributes like wide dynamic range, large memory, specialized I/O interfaces, or a combination of several features.

Time and Space Correction

Time and space correction are among the last steps in preprocessing operations and may not be necessary for many applications. However, if your application performs pattern recognition on sound or images, time and space correction are among the most critical steps. A signal's intensity may be filtered, but its relative position in time or space needs to be corrected so similar features are aligned with each other in preparation for the final computations. I will describe the more complicated of the two operations: geometric, or space, correction. Time corrections for speech applications are quite similar.

In image processing, once a sensor acquires an image, it is subject to intensity and geometric distortions. Thus, in any image-processing task, the first stage, which is part of preprocessing, is to identify the nature of the distortions and rectify them.

Intensity distortions are caused by external lighting variations, sensor imperfections, camera or scanner shading effects, detector gain variations, and so on. You can usually predict intensity distortions and correct them relatively easily using simple table-lookup techniques or digital filtering.

Geometric distortions, on the other hand, occur due to the nonlinearity or misorientation of sensors or to the inherent imperfections in optical instruments. In contrast to intensity corrections, geometric rectifications are complex and computationally intensive.

Synthetic aperture radar (SAR) and aerial imaging demonstrate some of the benefits of floating-point DSPs in implementing geometric corrections. Medical

continued

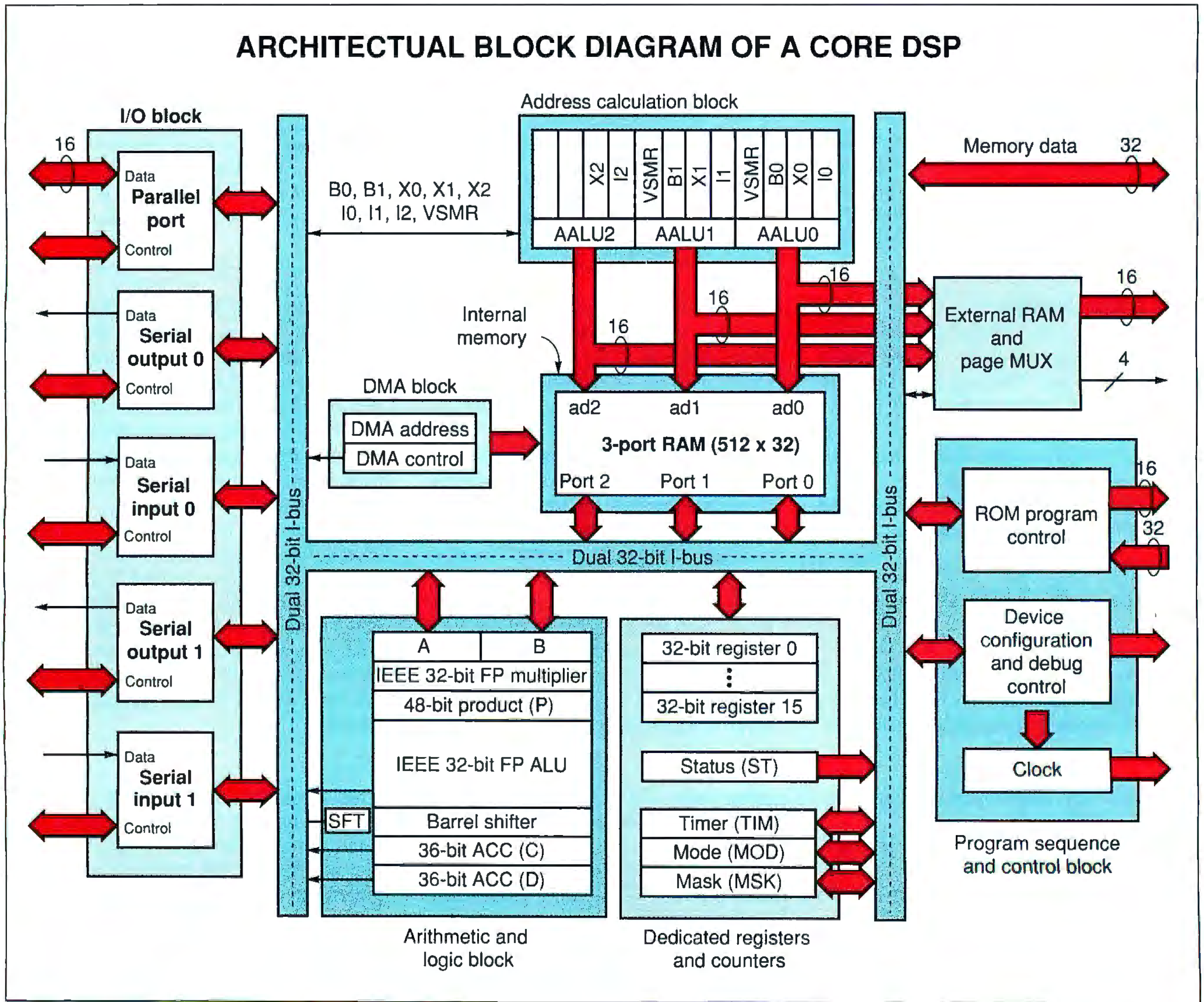
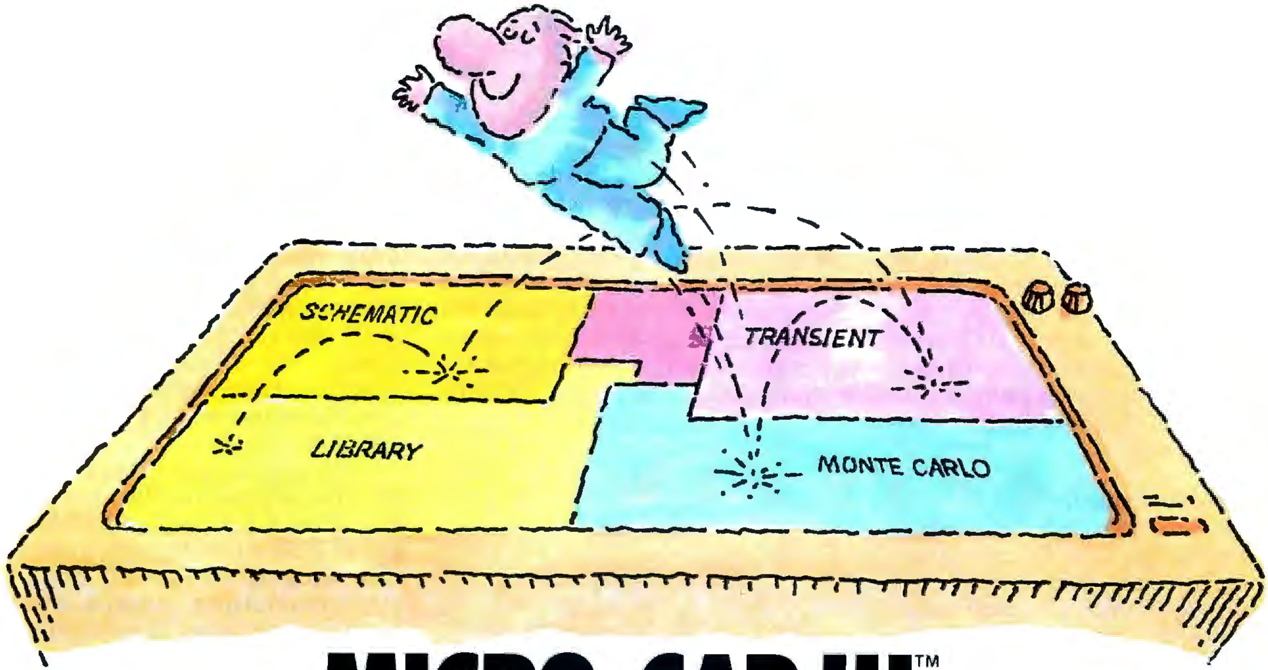


Figure 1: *Each core DSP consists of four functional modules: arithmetic and logic, address calculation, program sequence and control, and internal memory. All modules communicate with standard signals. Internal programmable logic arrays decode program instructions and generate control signals.*



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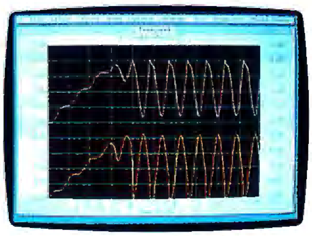
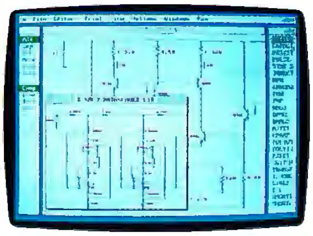


Transient analysis



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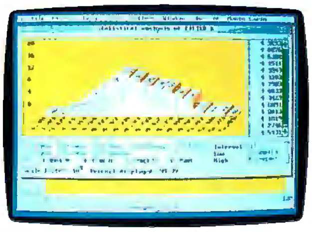

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imaging and machine vision are two other examples.

Aerial imaging and SAR typically use images from two different sensors for scene analysis. A remote sensor, such as an airplane or satellite, usually obtains radar and optical images. Such radar images are usually distorted and need correction before any decision can be made about the identity of the objects appearing in them.

Feature Extraction in Speech

Parameters that provide for a representation of the speech signal include formant frequencies, pitch, and intensity. You can estimate all three accurately and efficiently using techniques such as linear predictive code (LPC) analysis, short-time average magnitude, or homomorphic signal processing.

Formant frequencies, or formants, are the products of a phenomenon similar to the resonance effects observed with organ pipes or wind instruments. As sound propagates down the vocal and nasal tracts, the frequency selectivity of these tube-like organs shapes the frequency spectrum. As a result, certain frequencies are reinforced, and peaks occur in the spectrum of the signal. These peaks are the formant frequencies.

Determining formant frequencies is an essential part of speech analysis, because formants describe the spectral properties of the speech signal and therefore determine the particular sound that is produced.

When you speak, the glottis generates pulses of air that excite the vocal tract and thereby produce various sounds. The fundamental frequency with which these pulses are released is called the *pitch*; the resulting harmonics are called *pitch harmonics*. Pitch estimation is one of the most critical problems in speech processing because it provides information about the frequency of the pulses that generate voiced sounds.

Pitch estimation is a critical problem in speech processing.

The amplitude of the speech signal varies appreciably with time. In particular, the amplitudes of unvoiced segments are generally much lower than the amplitudes of voiced segments. The energy of the speech signal provides a convenient representation that reflects these amplitude variations.

You can use a variety of methods to estimate speech parameters, including LPC analysis. In applying LPC analysis to formant estimation, a set of p predictor coefficients called a_ks are computed by solving a set of linearly independent equations. These equations are represented in matrix form as $A \times \mathbf{x} = \mathbf{y}$, where A and $\mathbf{y}$ are known.

In the popular autocorrelation method, A is a $p \times p$ matrix of the autocorrelation values, $\mathbf{x}$ is a size p vector containing the predictor coefficients, and $\mathbf{y}$ is a $p \times 1$ vector of autocorrelation values. The autocorrelation sequence is computed directly from sampled speech waveforms.

Independent of the approach used in formulating the above LPC equations, matrix A exhibits useful properties that enable you to compute the predictor coefficient vector $\mathbf{x}$ in a robust and efficient manner. For example, if the autocorrelation method is used in setting up the LPC equations, then A is Toeplitz (a symmetric matrix in which all the elements along a given diagonal are equal). This property is exploited to obtain an efficient algorithm with which to solve the LPC equations.

Floating-point DSPs can perform the necessary computations for solving the

continued

Table 1: *Each core DSP is optimized for a certain application area. For example, the Type-2 core provides a special I/O interface for digital-audio applications, and the Type-3 core has special registers and a floating-point data format for image-processing applications.*

DSP CORES AND FEATURES

Core type	Type-1	Type-2	Type-3
ASIC DSP	MB86220	MB86224	A subset of MB86232
Application	Telecommunications application	Digital audio	Image processing
Machine cycle	75 ns	75 ns	75 ns
Operation speed	13.3 MIPS	13.3 MIPS	13.3 MIPS
Multiplication			
Floating-point:	$(1.8\times10^7)\times(1.8\times10^7)\rightarrow(2.4\times10^7)$	$(1.8\times10^7)\times(1.8\times10^7)\rightarrow(2.4\times10^7)$	$(2.4\times10^9)\times(2.4\times10^9)\rightarrow(2.4\times10^9)$
Fixed:	—	18-bit × 18-bit → 24-bit	24-bit × 24-bit → 32-bit
Internal RAM	256 words × 24 bits 2-page	256 words × 24 bits 2-page	256 words × 32 bits 512 words × 32 bits
Internal ROM	2 Kwords × 30 bits	2 Kwords × 30 bits	2 Kwords × 32 bits
Package	QFP[1] 80-pin PGA[2] 135-pin	QFP 80-pin	PGA 135-pin
Number of transistors	110K transistors	130K transistors	
Chip size	9.5 mm × 9.8 mm	9.8 mm × 10.4 mm	

[1] QFP = Quad flat pack.
[2] PGA = Pin grid array.

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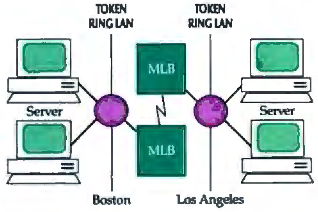

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Just a Moment

The method of moments is a way of describing the properties of an object in terms of its area, position, orientation, and other noninterpretive parameters (see figure A). Discrete moments are defined by the equation

$$M_{pq} = \sum_i \sum_j x^p y^q f(x,y)$$

where the order of moment equals $p+q$; x,y are pixel coordinates; and $f(x,y)$ represents the pixel brightness function. Zero- and first-order moments can be defined by these equations:

$$M_{00} = \sum_i \sum_j f(x,y)$$

$$M_{10} = \sum_i \sum_j x f(x,y)$$

$$M_{01} = \sum_i \sum_j y f(x,y)$$

In a binary image (black and white), the zero-order moment (M_{00}) is the same as the object's area. Because the object is not usually a single point, a precise definition of the term position must be given. In practice, the center of area, or center of mass (centroid), is used to specify position. The following equations give the centroid:

$$x_c = \frac{M_{10}}{M_{00}}$$

$$y_c = \frac{M_{01}}{M_{00}}$$

Although they are useful for some tasks, zero- and first-order moments prove inadequate when matching objects in the acquired image with objects in the reference image. This is because low-order moments vary according to scale, position, and rotation. Therefore, you must derive invariant moments such as $\phi_1, \phi_2, \ldots \phi_n$ for the object. These moments are unaffected by translation, rotation, and scale change.

Invariant moments also provide more information about the object than do zero- and first-order moments. The added information is useful in helping you to distinguish one object from another that may have similar properties. To compute invariant moments, you need to compute central moments and normalize them. Central moments are

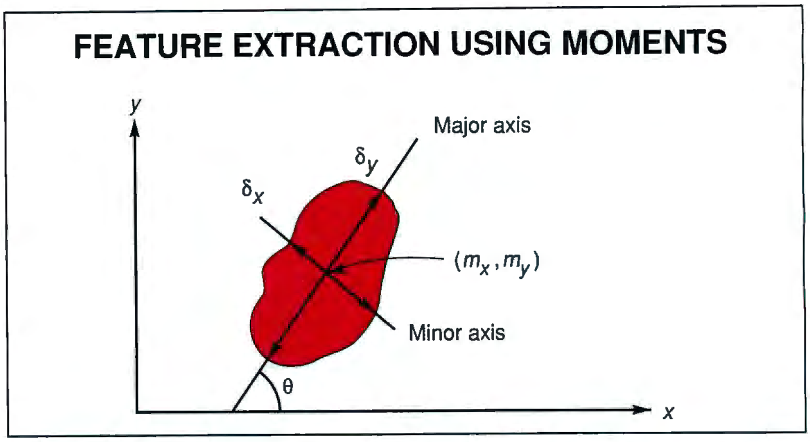

Figure A: *The method of moments is a way of describing the properties of an object in terms of its area, position, orientation, and other noninterpretive parameters. Note the calculation for the position of the centroid.*

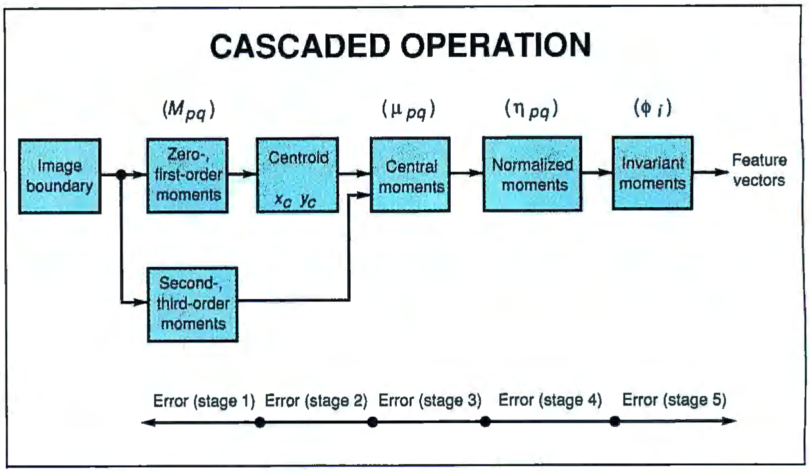

Figure B: *Subroutines in computation of invariant moments to create feature vectors. Each subroutine is computationally intensive and sensitive to computational error. However, each stage is connected to the other subroutines; computational errors, propagated through the stages, could have a major impact on system performance.*

discrete moments calculated with respect to the centroid. Both central and normalized moments can be derived from the following equations, respectively:

$$\mu_{pq} = \sum_i \sum_j (x-x_0)^p (y-y_0)^q f(x,y)$$

$$\eta_{pq} = \frac{\mu_{pq}}{\mu_{00}\lambda}$$

where $\lambda = (p + q)/2$.

From second-order normalized moments, you can derive a set of invariant moments:

$$\phi_1 = \eta_{20} + \eta_{02}$$
$$\phi_2 = (\eta_{20} - \eta_{02})^2 + 4\eta_{11}{}^2$$

Generating invariant moments is a cascaded operation that is particularly prone to generating overflow conditions and is also very sensitive to quantization errors along each stage of computation. As you can see, developing a software program to do these operations would not be a trivial undertaking. The unpredictability of input images and computational inaccuracies also add to the challenge (see figure B).

The large dynamic range provided in

FEATURE EXTRACTION USING FOURIER DESCRIPTORS

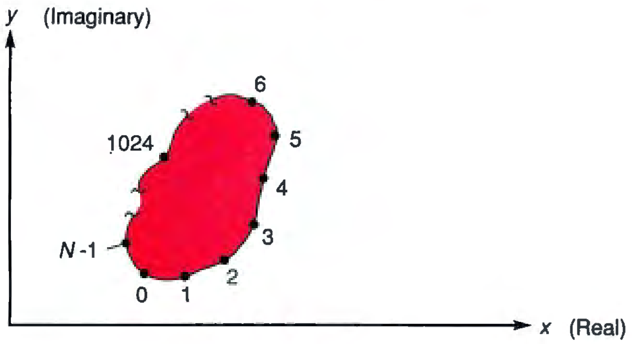

Figure C: *Fourier descriptors are a method of extracting information about an object using boundary points. You use the* x *and* y *coordinates of these points as the real and imaginary components of a complex number. Then, these complex numbers are used in a Radix-2 fast Fourier transform computation.*

IEEE-754 floating-point format (1500 decibels) along with flags for overflow, underflow, near zero, and near infinity, minimize the error along different sections of the system. It also speeds software development time by eliminating the need for scaling routines.

Fourier Descriptors

Fourier descriptors are another method for extracting information about an object. As in moment generation, boundary points are the inputs for Fourier descriptors (see figure C). These boundary points are mapped as imaginary and real points for Fourier analysis. The amplitude spectrum and phase are frequently used as parameters generated by Fourier transformation to distinguish between boundary shapes in the matching process.

The boundary is a series of complex numbers where x and y are the coordinates of points on an object's boundary, and N is the number of points.

$$f(i)=(x_i,y_i);\ i=0,1,2,\ldots,N-1$$

where x_i is the real component and y_i is the imaginary component.

The discrete Fourier transformation of the complex sequence is computed as

$$F(u) = \sum_{k=0}^{N-1} f(k) \exp(-j2\pi(\frac{ku}{N}))$$

Since F(u) is a complex series, the amplitude spectrum can be computed as

$$|F(u)| = |(\text{Real } F(u))\ 2 + (\text{Im } F(u))\ 2\ |^{1/2}$$

So, the equation of this phase is

$$\phi(u) = \arctan\ [\text{Im } F(u)\ /\ \text{Real } F(u)]$$

For normalized Fourier descriptors, you find the centroid using zero- and first-order moments, then you shift the origin of the existing coordinates to the centroid, and, finally, you compute phase and amplitude.

Fourier descriptors are invariant without requiring further computation. They are also useful because of certain properties in the Fourier domain: easy movement between the spatial and Fourier domains; size changes generated by multiplying by a constant; angle rotations accomplished by a simple multiplication; and translation accomplished by addition.

Broad Applicability

Use of invariant moments has been successfully demonstrated in a wide range of existing applications. In medical technology, there are reports that indicate 98 percent accuracy using invariant moments in identifying malignant tumors in chest x-rays. Similar results are shown in fingerprint recognition and optical character recognition.

LPC equations, arriving at numerical values for predictor coefficients. A subroutine function that simulates the vocal tract with an all-pole model then calls these coefficients. The output of this model is the spectral estimate of the input speech waveform. You can use lattice filters to implement the model.

If the spectrum is plotted, you should expect to see peaks at the formant frequencies. Thus, LPC analysis can be seen as a method of short-time spectrum estimation. Such techniques are widely applied outside the speech-processing field for this purpose. Once the spectrum is computed, a peak-detection algorithm can be devised to extract the formant frequencies.

LPC analysis is a parametric method of signal processing. In many applications, parametric models exhibit superior performance over nonparametric techniques such as "short-time average magnitude." The steps involved in estimating formant frequencies using LPC (autocorrelation formulation) are autocorrelation sequence calculation, LPC coefficient calculation, system function evaluation, and "peak picking."

In a practical implementation of these steps, most of the number crunching will occur while computing the predictor coefficients. Using the autocorrelation formulation, the number of multiplications required to calculate **x** is approximately $N + Np + p^2$. The system function is theoretically guaranteed to be stable. Nevertheless, this guarantee may not hold if the autocorrelation function is computed without sufficient accuracy. Then, the round-off encountered in computing the function can cause the autocorrelation matrix to become ill-conditioned.

Shapes and Features in Images

Before you're able to perform high-level image-processing tasks, such as object recognition, you might need several preprocessing steps to improve the quality of the image (i.e., enhancement) and several more to isolate the objects from their background (i.e., segmentation). Usually, segmentation itself involves multiple steps, such as separation, based on intensity, color, and contour edges.

Once you have identified the boundary of an object, you must extract features so that you can describe the object in a form other than that of the set of connected boundary points. In image processing, the most frequently used algorithms in feature extraction are those for invariant moments and Fourier descriptors (for

continued

A Two-Pronged Approach

Sound Processing

Fujitsu Microelectronics' MB86224 uses a floating-point data format (1.8×10^7) that meets typical digital audio requirements (no more than 120 decibels). It is designed to support the I^2C bus for high-fidelity digital-audio systems. Its floating-point capability makes it a candidate for carrying out calculations that require high accuracy.

The data format of this chip provides optimum precision and, consequently, minimum round-off error. Its architecture uses pointers to access the data structures. Therefore, it can delay and shift all data points simultaneously by incrementing the address pointer.

Moreover, the MB86224's advanced Harvard architecture and its two-stage pipeline enable the processor to perform floating-point operations at a high speed (6.75 million floating-point operations per second). The chip allows four levels of subroutine nesting in hardware, which increases computation speed by eliminating stack operations.

The MB86224 reduces and eliminates some of the shortcomings of IIR filters, such as limit cycle, quantization error, and instability, by providing 24-bit floating-point and fixed-point arithmetic capability. Also, the MB86224 has an interface that exhibits two-channel I/O capability providing concurrent multiple-speaker identification.

Image Processing

The MB86232 from Fujitsu Microelectronics is specifically designed for graphics and image-processing applications. Based on a two-stage pipeline Harvard-style architecture, it uses separate program and data buses to fetch data and execute an instruction simultaneously. Two internal 32-bit data paths allow faster data transfer within the device.

This chip contains four ALUs: one for arithmetic and logic operations, and three for different address units. These address units can access up to 1 megaword (4 megabytes) of data, 64K bytes of program space, and 512 by 32 bits of internal data memory, all at the same time. The MB86232 also features register files where temporary data can be kept for an immediate operation.

The MB86232 is also a 32-bit floating-point digital signal processor capable of performing 24-bit integer and 32-bit fixed-point multiply accumulate (MAC) in a single cycle (75 nanoseconds). Thus, for applications where the incoming signal is an integer, you don't need to convert it to floating-point. Using other existing floating-point DSPs requires routines to convert integer data into floating-point and vice versa.

For example, a 512- by 512-pixel image requires a 512 by 512 data-format conversion. Once the image is convolved with a 3×3 mask in floating-point format, the output image needs to be reformatted again (8 bits for gray scale, 24 bits for color) for display purposes. Regardless of the time spent in convolution, extra time is wasted in converting from one format to the other, twice. Consequently, the implementation speed of such preprocessing is half to one-third that of the MB86232.

The MB86232 fully conforms to the IEEE-754 floating-point standard and makes overall system design easier by providing compatibility with existing hardware components and transportability for many software programs that use the standard. It implements moment calculations.

To facilitate complex I/O functions and keep the hardware/software aspect simple, the MB86232 provides two serial inputs, two serial outputs, and one parallel port. The serial ports are programmable for 8-, 24-, and 32-bit data formats.

Up to 16 MB86232s can be linked together via message passing, a unique feature of the MB86232 parallel port for multiprocessing tasks used in pattern-recognition systems.

The MB86232 is Fujitsu's high-end 32-bit floating-point DSP. It offers dual-accumulation capability (i.e., two ALU accumulators), which makes this chip suitable for geometric correction computations. (The MB86232 assembly code for implementing the geometric correction procedure is available from Fujitsu.)

The advantage of having two accumulators for carrying out such computations lies in the fact that the two coordinates can be computed in a semiparallel mode by jumping back and forth between the equations, keeping the intermediate results inside the pipeline, and the sum of individual products in different accumulators. All MAC functions can be done with either accumulator.

more details on these algorithms, see the text box "Just a Moment" on page 268).

DSP ICs

In the past, due to the density of data and the large amount of computation involved, feature extraction was best performed on mainframes or minicomputers. The emergence of VLSI chips that support IEEE floating-point math provides an architecture that supplies feature-extraction capabilities on a microcomputer. This architecture performs parallel operations in a pipelined fashion. It multiplies and adds rapidly (in a 75-nanosecond instruction cycle), which is essential for filtering, moment, and Fourier analysis. It generates complex addressing, such as bit-reversed and circular for complex Fourier transforms. It performs full IEEE floating-point arithmetic and logic operations.

The IEEE-754 format is the accepted standard among 32-bit CPUs, math coprocessors, and many high-performance support ICs. Fujitsu Microelectronics has developed IEEE-standard floating-point ASIC DSPs for sound and image processing. Two of these chips are described in the text box "A Two-Pronged Approach."

Pattern-Recognition Architecture

Floating-point DSPs have been shown to provide enormous benefits in implementing preprocessing and feature-extraction algorithms used for sound and image processing. Some key advantages of floating-point ASIC DSPs in these massive number-crunching operations are high-precision arithmetic capability, special addressing modes (e.g., direct, indirect, bit-reversed, circular, and indexed), and software programmability. Performing pattern recognition with floating-point DSPs also has some advantages.

Pattern-recognition systems require a high data transfer rate, which ASIC DSPs support through multiple data paths within the device (two 32-bit internal data buses), several serial and parallel I/O ports, and direct memory access (DMA) capabilities.

In speech-recognition systems, DSPs have been used for digital simulation of neural networks. Four of them are configured in a ring-lattice, multiple-instruction multiple-data, neural network architecture used in an accelerator board for personal computers. In image-processing systems, you can partition images as well as tasks and assign various parts of them to several DSPs to

continued

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M1-B

Circle 241 on Reader Service Card

Glossary

Adaptive filtering A class of filters whose coefficients are updated according to a performance criterion.

All-pole model A system model whose characteristics are independent of the numerator, which is constant, but rather are a function of the poles in the denominator.

Autocorrelation A mathematical representation of the degree of correlation between signal samples.

Bilinear interpolation A method by which an interim missing sample is estimated as a combination of known adjacent (i.e., in orthogonal directions) samples.

Bit-reversed addressing An addressing mode that facilitates in-place fast Fourier transform computations by reordering the addresses for input or output data in "butterfly" calculations.

Bit-slice processors A group of general-purpose processors that allow for change in the data and instruction size by cascading several ICs.

Circular addressing An addressing method in which recurrent data is read from the same memory locations previously used, thereby reducing required memory size.

Convolver A hardware device that performs convolution.

Correlation The degree of interrelation between two signals.

Correlator A hardware device that performs correlation.

FIR filter Finite impulse response filter: a class of filters that have finite-duration unit-pulse response. The output of an FIR filter is a function of input data and filter coefficients only.

Formants The resonance frequencies of the vocal-tract tube.

Homomorphic analysis A nonlinear operation using the superposition property of convolution to extract the original components of a signal.

I²C An industry-standard serial-communications protocol developed by Philips Corp.

IIR filter Infinite-duration impulse response filter: Filters whose output is a function of input data, filter coefficients, and previous output values.

Ill-conditioned matrix A matrix whose determinant closely approaches zero. Therefore, small perturbations may cause the matrix to become noninvertible.

Limit-cycle A problem associated with recursion, causing a filter to behave in a nonlinear manner.

Linear predictive analysis A technique by which a signal sample $s(n)$ is predicted from the sum of p linearly weighted previous values.

Moments Statistical parameters that describe the shape of a distribution function. They are used in mechanical physics and image processing.

Nyquist frequency Minimum sampling rate required to prevent aliasing (overlapping) of signal frequencies. It is greater than or equal to twice the maximum input frequency.

128-FIR An FIR filter with $N=128$ (128 "taps").

Parametric method Describing a signal in terms of a set of parameters.

Pitch Fundamental frequency of the harmonics exhibited by the spectrum of the glottal-air volume and velocity.

Quantization error Error caused by representing a number with a limited number of bits, which results in reduced precision.

Radix-2 FFT A fast Fourier transform algorithm that uses two inputs and two outputs for each butterfly computation.

Short-time average magnitude A method of representing amplitude variations of a signal segment in time domain by summing the absolute values of intensities over a finite time interval.

Time-domain convolution A process that modifies a signal by multiplying it with a function, followed by integration over a specified time interval.

increase the overall speed. Communication between different modules can become a significant design hurdle in both software and hardware.

Communication between several DSPs can be accomplished using a parallel port. Each DSP has a unique identification number represented in 4 bits. When the parallel port is receiving, it checks the first 4 bits of the data packet (unit identification). If the internal identification matches this ID number, then it receives the rest of the information. In transmit mode, the DSP sends the ID number associated with the destination DSP, followed by the data. This operation is called message passing.

Maximum Flexibility

Several ASIC DSP devices have been developed for telecommunications, sound processing, and image processing. These devices provide maximum flexibility in system design: They are software-programmable as well as hardware-reconfigurable.

The floating-point capability of these devices provides superb quality of sound and images in existing applications and has paved the way for analyzing sound and images as well. ■

Editor's note: *Various DSP assembly language programs are available on BIX.* *See page 5 for details.*

ACKNOWLEDGMENT

I would like to thank my colleagues at Fujitsu Microelectronics, Inc., especially Shervin Kheradpir and Donna White, for their full support in helping me prepare this article.

Bobby Saffari is a senior applications engineer at Fujitsu Microelectronics, Inc. (San Jose, CA), where he is responsible for supporting Fujitsu's digital signal processors and development tools. He holds B.S.E.E. and M.S.E.E. degrees in signal processing and computer architecture from California State University at Northridge. He can be reached on BIX c/o "editors."

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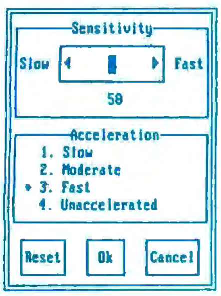

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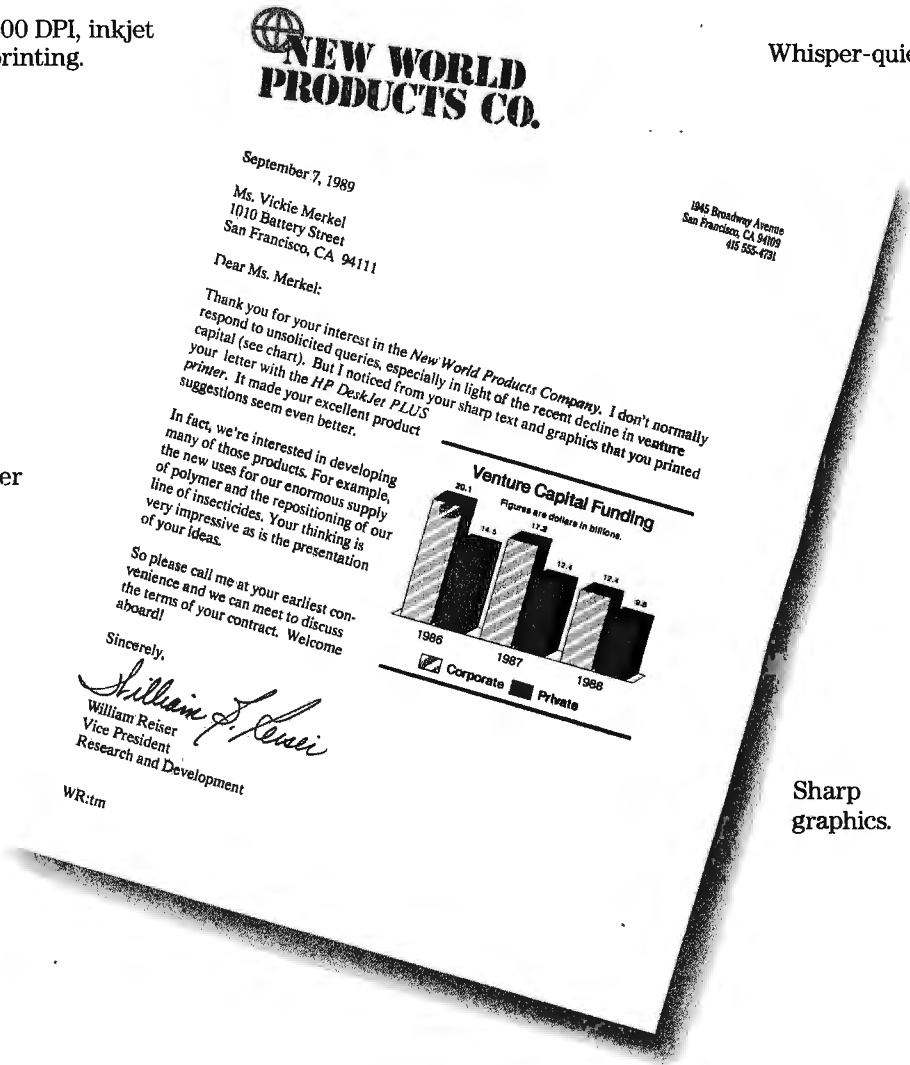
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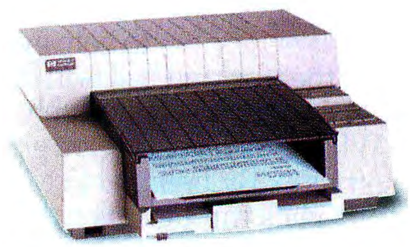
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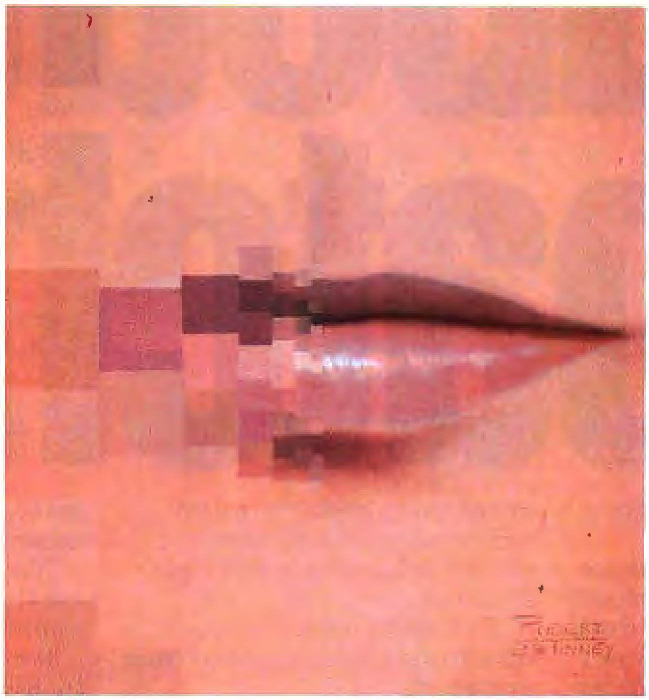
Beyond Pattern Recognition

Practical voice-to-text systems rely as much on knowledge engineering as on speech-recognition technology

Raymond Kurzweil



Creating written documents is an activity practiced by almost everyone in offices, schools, and homes. Tens of billions of dollars are spent each year in creating original written works, from interoffice memoranda to multivolume reference works. In fact, just copying all these documents is a $25-billion-a-year industry.

For most people, creating written documents is an arduous task. Automating this task by dictating to a computer-based machine and seeing it appear on-screen has obvious advantages over conventional methods in terms of speed, accuracy, and convenience.

A substantial part of many professionals' jobs involves creating routine reports, including memos, letters, and E-mail. A routine report differs from other documents in that it has a predictable—but not rigid—structure and an internal logic to its organization. The underlying framework of structure and logic can be exploited in the design of an automated voice-to-text system.

Hunt and Peck

Current methods for text creation are fundamentally inefficient and often inadequate for the job. The vast majority of professionals do not possess good typing skills; they must choose between handwriting, hunt-and-peck typing, or dictating to tape. All these approaches have obvious limitations.

Writing drafts by hand or by hunt-and-peck typing is slow; actual throughput is generally under 10 words per minute. Then comes the time-consuming cycle of correction and editing as the draft is typed or entered into a word processor. Errors are often introduced due to poor legibility. Turnaround time can be days, depending on the number of correction cycles and the typist's workload and knowledge level.

When dictating to a secretary or tape, most people find it difficult to create text because they can't see what they are doing. It's hard to create a document of even moderate complexity without being able to view the text that has already been composed. In addition, conventional dictation requires substantial clerical time, as well as follow-up edit and review by the text creator. Skilled transcriptionists, especially those in the medical, legal, or technical fields, are increasingly hard to find. Transcription costs—particularly during evenings, vacations, and weekends—can be prohibitive.

Look Ma, No Keyboard

Report creation on a computer screen with automatic speech recognition (ASR) technology provides significant productivity gains compared with the other methods available.

continued

ILLUSTRATION: ROBERT TINNEY © 1989

AN ASR-GENERATED MAMMOGRAPHY REPORT

SAY	DISPLAY
"today's date" "mammography" "bilateral"	4/11/1989 MAMMOGRAPHY (bilateral)
"routine"	A low-dose film technique was used. Cephalocaudad and modifed lateral views were obtained.
"diffuse nodularity"	Both breasts show a very prominent duct pattern with diffuse nodularity throughout. Such diffuse nodularity makes the breasts difficult to evaluate.
"no focal lesions"	There are no dominant masses or clustered calcifications on either side.
"obtain outside study"	The patient gives a history of previous mammography elsewhere. If these could be obtained for comparison, it would be helpful to exclude any interval change.
"signature"	John H. Jones, M.D. 9:18:22 5/25/1989

Using automatic speech recognition (ASR), creating this routine mammography report required less than 30 seconds and only eight spoken words and phrases.

The spoken word is probably the most powerful mode of communication. It is the first method you learn, and human factors studies confirm that it is by far the most rapid form of communication.

Creating reports with ASR combines the speed advantage of dictation with the immediate inspection and correction of handwriting. It is four to six times faster than writing drafts by hand or hunt-and-peck typing. Even for the minority of professionals who type well, ASR is a faster way to get the report-writing job done. It eliminates all the follow-up steps because a final report—the ultimate goal—can be created in a single step. ASR report creation eliminates the cost of transcription and is available around the clock, seven days a week.

ASR report creation is of special value to people hampered by such transcription problems as high cost, slow turnaround, and poor overall report quality. Two fields where ASR has been put to outstanding use since 1987 are radiology and emergency medicine. See the figure for an example of a routine medical report that can now be created in less than a minute using voice technology.

The potential for large-vocabulary ASR is enormous given the number of people who regularly produce routine reports. Other likely application areas for early implementation of ASR include pathology and surgical notes in health care, law, and certain financial services, such as real estate and insurance.

Speech Facts

Speech is created by the human vocal tract which, like a complex musical instrument, has a number of different ways of shaping sound. The vocal cords vibrate, creating a distinctively pitched sound. The length and tautness of the vocal cords determines the pitch in the same way that the length and tautness of a violin or piano string determines its pitch. You can control the tautness of your vocal cords, giving you the ability to sing. You shape the overtones produced by your vibrating vocal cords by moving your tongue, teeth, and lips, which has the effect of changing the vocal tract's shape.

The vocal tract is a chamber that acts like the pipes in a pipe organ; the harmonic resonances emphasize certain overtones while diminishing others. You also control a small piece of tissue called the *alveolar flap*, which opens and closes the nasal cavity. When the alveolar flap is open, the nasal cavity provides an

continued

additional resonant chamber similar to the opening of another organ pipe.

In addition to the pitched sound produced by the vocal cords, you can produce a noise-like sound by the rush of air through the speech cavity as well as by the action of your tongue and lips. This sound doesn't have specific overtones but is, rather, a complex spectrum of many frequencies mixed together. Like the musical tones produced by the vocal cords, these noise sounds are also shaped by the changing resonances of the moving vocal tract.

The elements of your vocal tract allow you to create the varied sounds that comprise human speech. While many animals communicate with others of their species with sound, humans are unique in their ability to shape sound into language. Vowel sounds (*ahh*, *eee*, etc.), for example, are produced by shaping the overtones from the vocal cords into distinct frequency bands called *formants*. Sibilant sounds (*s*, *z*, etc.) are created by the rush of air through particular configurations of tongue and teeth. Plosive consonants (*p*, *t*, *k*, etc.) are transitory sounds created by the percussive movement of lips, tongue, and mouth cavity. Nasal sounds (*n* and *m*) are created by resonances of the nasal cavity.

Each of the several dozen basic sounds, called *phonemes*, requires an intricate movement involving precise coordination of the vocal cords, alveolar flap, tongue, lips, and teeth. Humans typically speak about three words per second, so, with an average of six phonemes per word, you make about 18 complex phonetic gestures each second. You do this without thinking about it, of course: Thoughts remain on the conceptual (i.e., highest) level of the language hierarchy. You did, however, think a lot about how to make speech sounds—and how to string them together meaningfully—in the first two years of life. This is another example of the sequential (logical) conscious mind training our parallel (pattern-recognition) mind.

The mechanisms described above for creating speech sounds—vocal-cord vibrations, the noise of rushing air, articulatory gestures of the mouth and tongue, the shaping of the vocal and nasal cavities—produce different rates of vibration. A physicist measures these rates of vibration as frequencies; humans perceive them as pitches. So, while speech is considered to be a single time-varying sound, it is actually a composition of many different sounds, each of which has a different frequency or pitch.

Automated Listening

With this insight into how human speech works, most ASR systems start by breaking up the speech waveform into a number of different frequency bands. A typical commercial or research ASR system will produce between three and several dozen frequency bands. The "front end" of the human auditory system does exactly the same thing. Each of the nerve endings in the cochlea (inner ear) responds to different frequencies and emits a pulsed digital signal when activated. Overall, the cochlea differentiates several thousand overlapping frequency bands, giving the human auditory system its extremely high degree of sensitivity to frequency. Experiments have shown that increasing the number of overlapping frequency bands in an ASR system—and thus bringing it closer to the human auditory system—substantially increases the ability of that system to recognize human speech.

Typically, parallel processing is used in this front-end frequency analysis, although not as massively as in vision systems, since the quantity of data is much smaller. (To approach the thousands of frequency bands used by the human auditory system would require massive parallel processing.) Once the speech signal has been transformed into the frequency domain, it is *normalized* (adjusted) to remove the effects of loudness and background noise. At this point, the system can detect a number of features of the frequency-band signals, as well as consider the problems of segmentation and labeling.

One popular detection technique is minimal property extraction. The feature set can be either the normalized frequency data itself or various transformations of this data. In matching such minimal property sets, the system needs to consider the phenomenon of *nonlinear time compression*. When you speak, you change your speed, depending on context and other factors. If you speak a word more quickly, you do not increase the rate evenly throughout the entire word. The duration of certain portions of the word, such as plosive consonants, will remain fairly constant, while other portions, such as vowels, will undergo most of the change.

In matching a spoken word to a stored template, the system needs to align the corresponding acoustic events, or the match will never succeed. This problem is similar to matching visual cues in fusing the stereo images from your two eyes. A mathematical technique called *dynamic programming* has been developed to accomplish this temporal alignment.

High-level features are also used in

ASR systems. Speech is made up of strings of phonemes, which comprise the basic "alphabet" of spoken language. In English, there are about 16 vowel and 24 consonant sounds; for the most part, the Japanese language uses only five vowel and 15 consonant sounds. The nature of a particular phoneme—such as *ahh*—is an abstract concept, just as the inherent nature of a printed character—such as *A*—cannot be simply defined. Identifying phonemes in human speech requires intelligent algorithms and recognition of high-level features similar to the recognition of the loops and concavities found in printed characters.

The task of segmenting speech into distinct time slices representing different phonemes is also formidable. The time-varying spectrum of frequencies characterizing a phoneme in one context may be dramatically different in another. In fact, in many instances, no time slice corresponding to a particular phoneme can be found; the phoneme is detected only by the subtle influence it has on phonemes around it.

As in vision and character recognition, both high- and low-level features have value in speech-recognition systems. In recognizing a relatively small vocabulary (e.g., a few hundred words) for a single speaker, low-level feature detection and template matching—using dynamic programming—is usually sufficient. Most small-vocabulary techniques use this approach. For the more advanced systems, a combination of techniques is usually required—generally multiple experts and an expert manager who knows the strengths and weaknesses of each.

High-level context experts are also vital for large-vocabulary systems. For example, phonemes must appear in a certain order; many sequences are impossible to articulate (try saying *ptkee*). More important, only certain phoneme sequences will correspond to a word or word fragment in the language. On a higher level, the syntax and semantics of the language put constraints on possible word orders. While the set of phonemes is similar from one language to another, context factors differ dramatically. English, for example, has over 10,000 legal syllables, whereas Japanese has only 120.

Learning is also vital in speech recognition. Adaptation to the particular characteristics of each speaker is a powerful technique in each stage of processing. Learning must take place on a number of different levels: the frequency and time relationships characterizing each phoneme, the dialect (pronunciation) patterns of each word, and the syntactic patterns of possible phrases and sentences.

Speech recognition encompasses the full paradigm of pattern recognition: parallel processing in the front end, segmentation and labeling, multiple experts on both high and low levels, expert management, disambiguation by context experts, and learning from actual recognition examples. But while the paradigm is the same, the content is dramatically different. Only a small portion of the technology in a successful ASR system consists of classic pattern-recognition techniques; the bulk of it consists of extensive knowledge about the nature of human speech and language—the shape of speech sounds and the syntax, semantics, and phonology of spoken language.

ASR Parameters

Three fundamental attributes characterize a particular ASR system: vocabulary size, training requirements, and ability to handle continuous speech.

Vocabulary size indicates the number of different words that a system can handle at one time. Text creation requires a large basic vocabulary as well as the ability to add additional words to the active personal vocabulary of each user. For most applications other than free-form text creation, small vocabularies suffice.

Most ASR systems require you to train the system on your own particular pronunciation patterns. Typically, you provide the system with one or more spoken samples of each word in the vocabulary. However, for large-vocabulary systems, speaking every word in the vocabulary is often not practical. It is preferable that the ASR system can infer how you are likely to sound words that you have never actually spoken to the machine. Then, you need to train the system on only a subset of the full vocabulary.

Some small-vocabulary systems have been preprogrammed with all the dialectic patterns anticipated from the population expected to use the system and thus don't require any prior training by each user. This capability, called *speaker independence*, is generally required for telephone-based systems where many users can access a single system.

Most commercial systems to date require you to speak with brief pauses—usually around 100 milliseconds—between words. This helps the system make a crucial segmentation decision—where words start and end. Speaking with such pauses reduces the speed of a typical speaker by 20 to 50 percent. ASR systems that can handle continuous speech exist, but they are currently limited to small vocabularies. Continuous-speech

continued

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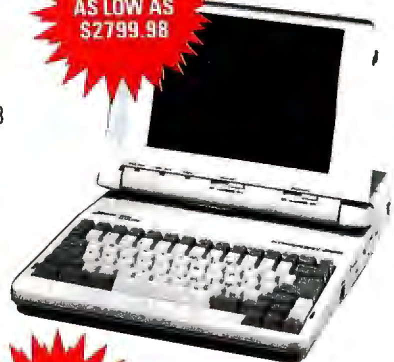

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The Translating Telephone

Someday, you will be able to call anyone in the world and talk—regardless of the language the other person speaks. Three technologies are necessary to bring this about: automatic speech recognition (ASR), language translation, and speech synthesis. All three exist today, but not nearly in sufficiently advanced form.

The Holy Grail of ASR would feature a large, relatively unrestricted vocabulary; it would accept continuous speech input; and it would provide speaker independence (i.e., the system would not need to be trained by each user). ASR would have to attain this level to implement a translating telephone.

Conceivably, speaker independence could be eased into early versions of this system. Users of this capability might be willing to spend 15 minutes or so training the system on their voices. Such enrollment would be required only once. Combining the first two elements—large vocabulary and continuous speech—will take us to the early 1990s. Adding speaker independence will take us later into that decade.

Language translation would require only the ability to translate text, not speech, since the ASR technology would be translating the speech input into written language. The language-translation capability would not require literary-quality translations, but it would have to perform completely unassisted. Language-translation systems today require human assistance. Completely automatic translation of sufficient quality will probably become available around the same time that the requisite ASR is available.

Every pair of languages requires different software, and, indeed, going from French to English is a different problem than going from English to French. While many aspects of translation will be similar from one set of languages to another, language-translation technology will vary in quality and availability, depending on the languages involved.

Speech synthesis is the easiest of the three technologies required by the translating telephone. In fact, it is available today. While not entirely natural, speech generated by the better synthesizers is quite comprehensible without training. Naturalness is improving, and speech-synthesis systems should be entirely adequate by the time the necessary ASR and language-translation systems are available.

Thus, you could expect translating telephones with reasonable levels of performance for at least the more popular languages soon after the turn of the century. With continuing improvements in performance and reductions in cost, such services could become widespread by 2010.

The impact will be another major step in achieving the "global village" envisioned by Marshall McLuhan in 1968. Overcoming the language barrier will result in a more tightly integrated world economy and society. We will be able to talk more easily to more people. Of course, our ability to misunderstand each other will remain unimpaired.

systems that can handle large, relatively unrestricted vocabularies are expected by the early 1990s.

Other characteristics that are important in describing practical ASR systems include accuracy rate, response time, immunity to background noise, requirements for correcting errors, and integration of the speech-recognition capability with specific computer applications. The significance of these characteristics can be surprising. Take, for example, accuracy rate and error-correcting requirements. After extensive observation of users of an ASR radiology reporting system, designers concluded that users prefer—*and perceive as more accurate*—a system that is 95 percent accurate but whose errors can be easily corrected, over a 98-percent-accurate system whose errors require much more time and effort to correct.

Equally surprising are the problems that occur in integrating speech-recognition capability with specific computer applications, such as medical-report generation. First of all, it is generally not desirable to simply insert a speech-recognition system as a front end to ordinary computer applications. The human-factors requirements for controlling computer applications by voice are substantially different from those of more conventional input devices, such as keyboards. The design of the overall system needs to take this into account. For the integration of ASR with report-generation applications in particular, a procedure known as *knowledge engineering* is almost indispensable.

Enter Knowledge Engineering

At the beginning of the systems development process, a knowledge engineer interviews the appropriate domain experts—individuals with expertise in a particular profession, such as medicine or law. The knowledge engineer writes down the relevant knowledge, vocabulary, and decision-making rules used by that human expert. The result would be a *knowledge base* that includes the words, phrases, and underlying logic used by a particular profession.

While human experts can solve problems within their domains of expertise, they often cannot explain the steps they follow to accomplish these tasks. The skill required of the knowledge engineer is to extract and codify the decision-making process from the domain experts, despite their not being consciously aware of many elements of this process.

Once the knowledge base is designed, end users, such as doctors, lawyers, or other professionals with little or no previous computer experience, can use voice input to generate routine reports in a way that reflects their normal approach to these tasks. The knowledge base allows end users, with little or no typing or computer experience, to use voice productively. By capturing knowledge of the application in the system, the user is free to concentrate on the job at hand. The system knows the basic framework of the task to be performed. This matches the way most professionals already work with their secretary or transcriptionist.

Building a knowledge base for voice reporting required developing these components: domain-specific vocabularies, trigger phrases, and an underlying logical framework.

Domain-Specific Vocabularies

According to vocabulary studies done by Kurzweil Applied Intelligence (which develops voice-to-text medical reporting systems) as well as other published studies, typical text creators use vocabularies of less than 10,000 words in their written work in a given profession. The actual words vary by field (e.g., doctors, lawyers) and by individual specialties within those fields (e.g., within radiology: neuroradiology, mammography, and chest x-ray).

With the current speaker-dependent technology, you must train the system with all the words you will be using, although algorithms have been developed

continued

that can reduce voice training by at least one order of magnitude. Part of knowledge engineering involves determining which words should be provided in the starting core vocabulary.

A knowledge engineer can maximize the vocabulary coverage—that is to say, the probability that the word spoken is in the active vocabulary—by including the words most frequently used by the particular end user. By starting with the right set of words, end users can do their work with minimal interruption. A vocabulary can be easily customized to meet individual needs and style by adding or modifying words as needed.

Trigger Phrases

A single spoken word or phrase can "trigger" an entire predefined report segment, with fill-in-the-blank capability for customization. For example, in a medical report, time-saving triggers allow the doctor to speak a single word or short phrase, such as "soft-tissue swelling," to place a predefined definitive report entry of many words on the screen.

Using trigger phrases in combination with word-by-word dictation provides the flexibility to generate complete custom reports quickly by using just a few spoken words.

Trigger phrases and their translations can be customized for each individual with a trigger editor. You can define new trigger phrases by specifying a trigger phrase name and the appropriate translation. Triggers can also include multiple choices of alternatives embedded within them, as well as additional specificity in a highlighted fill-in-the-blanks field. You can fill in these fields using either word-by-word dictation or other triggers, allowing the nesting of trigger phrases.

Underlying Logical Framework

Every report has a structure with a predictable sequencing of information. The

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underlying logical framework component of the knowledge base must capture this information flow.

For example, in a voice-to-text medical reporting system, the emergency medical report might begin with the name of the complaint. Then the doctor would describe one or more of the following: past medical history, other symptoms, social and family history, and allergies.

Using a voice-to-text reporting system that incorporates a reporting hierarchy into its software, an emergency medical doctor would move through the text on the screen section by section, inserting the appropriate information or choosing from lists of options. Generating the report is simplified by the fact that the underlying framework defines the format for each report segment, including tabs, spaces, and margin settings.

Since the system knows which exam has been chosen at any given time, a spoken word, such as "normal," can have different translations that vary as a function of the initial complaint. "Normal" means something quite different in an ear exam than it does in an eye exam. The system keeps track of the context.

Furthermore, if a patient came to the emergency room complaining of a headache, the program would prompt the doctor to describe the location of the headache, whether there is blurred vision, and, if so, for how long. It will not prompt him to indicate, for example, swelling in the lower leg, chronic back pain, or other symptoms not normally associated with a headache. In this way, the system actually guides the doctor through the reporting process.

It is important to realize that, within the rules, there is tremendous flexibility. For example, in sections of the report where the predefined triggers are too limiting, the doctor can use word-by-word dictation. The doctor can also edit the report by voice.

Capturing the underlying logic is perhaps the most difficult step in the knowledge-engineering process, but it is critical in building a system that is natural and fast for the end user.

Digital Interfacing

Routine reports—along with phone calls and meetings—are key tools for communication. Besides making the creation of these reports faster and more efficient than ever before, ASR has an added benefit: Because voice-generated reports can be stored and transmitted in a digital format, it is now possible to distribute the reports electronically within and among organizations faster than was previously possible. This is being done by interconnecting ASR systems to advanced, organization-wide information systems.

In the past, a radiological report might be dictated to tape and then transcribed by a skilled clerical worker, often with a delay of several days. Meanwhile, a referring physician—who needs the report fast to pursue urgent treatment—might be forced to proceed on the basis of a verbal or scribbled handwritten report from the radiologist. By the time it becomes available, the typed report might be just an administrative formality.

By interconnecting an ASR system to a hospital information system, physicians at some U.S. hospitals have completed voice-generated reports printed out on their patients' floor as soon as the radiologists, working in their departments, have finished reading the films. This rapid availability of printed reports eliminates disruptive "call backs"—when referring physicians who can't wait for typed reports call radiology departments to get urgently needed results.

In a further refinement designed to tighten a hospital's information loop, the radiological report—entered on an ASR system and stored as a computer file—can be converted into synthetic speech and read back over the phone to referring physicians who call in for results.

Visions of the Future

While ASR systems continue to fall far short of human performance, their capabilities are rapidly improving, and commercial applications are taking root. As of 1987, there were ASR systems that could either recognize a large vocabulary (10,000 words or more), recognize continuous speech, or provide speaker independence (no user training). None, however, could provide more than one of these capabilities at a time.

By the early 1990s, I expect it to be possible to combine two of these attributes in the same system. In other words, you will see large-vocabulary systems that can handle continuous speech while still requiring training for each speaker; there will be speaker-independent systems that can handle continuous speech but only for small vocabularies; and so on. The Holy Grail of speech recognition is to combine all three of these abilities, just as humans do. (See the text box "The Translating Telephone" on page 284.)

The combination of ASR and knowledge engineering is a practical reality today. And in the future, you can expect to see many more applications of this technology. ■

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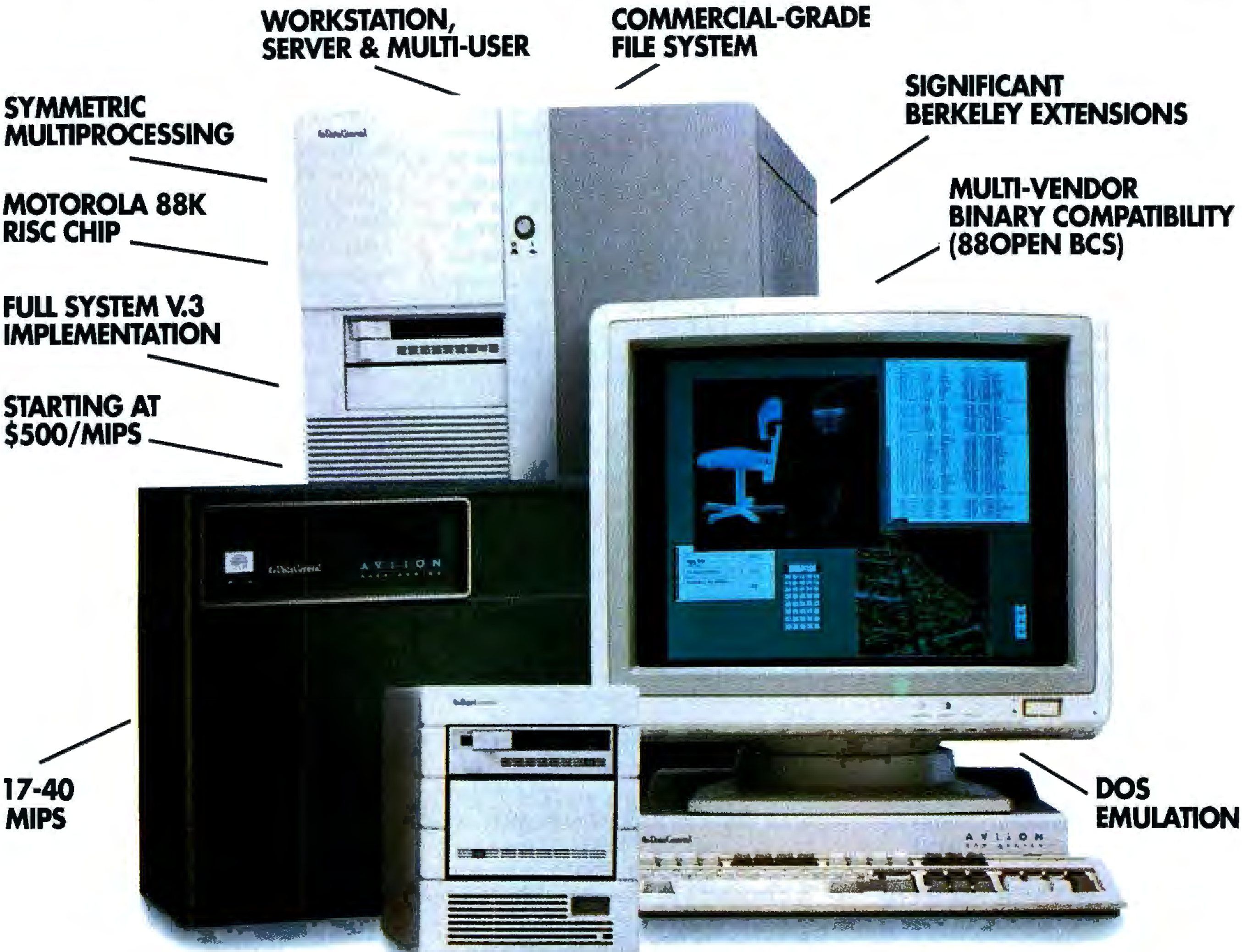

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Changing Perceptions of Reality

Image editing lets you interactively improve, rearrange, modify, and adjust images any way you want

Benjamin M. Dawson

Image processing is the science of analyzing and changing images for human or machine use. It is used, for example, to enhance images from underseas robots (see "Finding the Titanic," March 1986 BYTE) or to automatically inspect parts. Image processing usually improves the image or extracts information from it rather than modifying the image or adding information.

You can, however, also use the algorithms and methods developed for digital image enhancement and analysis to edit and modify images. I'll explore some image processing methods and how they apply to image editing. (The text box "Imaging Tools" on page 294 describes the hardware and software needed to try some of these methods.)

For the methods I describe, I assume that the images have been sampled into an array of pixels, and the intensity of each pixel has been quantized (sampled in intensity) to at least 6 and preferably 8 bits.

This intensity range generally lets you apply image-processing algorithms based on continuous mathematics to the image. This range is also sufficient to fool the human eye into seeing the image as continuous in intensity when it is displayed. Applying these methods to lower-resolution images, perhaps acquired with a desktop scanner, might give results that are noisy or unsatisfactory due to quantization errors.

Digital Image Editing

Image editing is used to interactively improve, rearrange, modify, and adjust images for human viewing. You can use image-processing methods to adjust contrast, cut and paste, or change the shape of image areas. Digital image editing is used professionally to replace tedious photographic methods. A digital or computer "darkroom" can do far more than the photographic darkroom, and usually much faster.

Image-processing operations that modify a pixel value based only on its original value are called *point processes*. The point processes change an image's brightness and contrast, make it into a solarized or negative image, and so forth. Listing 1 contains a code fragment for changing a triangular area of an image into its negative, as shown in photo 1. The image is sequentially scanned, and pixel y addresses increase downward while x addresses increase to the right. This video-coordinate system is commonly used in image frame buffers and matches the way in which a TV is scanned.

In this example, the point process depends on the original pixel intensity and its x and y locations. The modification occurs only if the image's pixel y address

continued

is greater than its x address. Point transforms can be any function of the original pixel intensity and its x,y address. These functions can be quite complex and impossible to do in a darkroom.

Output lookup tables (LUTs) perform point processing independently of the pixel's address and do so without modifying its value. For example, with 8-bit pixels, loading output LUTs (starting at table address 0) with the values 255, 254, . . ., 0 displays the entire image as its negative. LUTs are quick to load and are used to interactively adjust all the pixel values.

Listing 2 contains a code fragment for interactively brightening the entire image by using output LUTs. You can make an LUT transformation permanent by using the LUT values to change the

With a digital "darkroom," you can do far more than you can in a photographic darkroom, and usually much faster.

pixel values in the frame buffer (see `ptransform()` in table A in the text box "Imaging Tools" at right).

Area Processing

If the image-processing method uses small areas of pixels as input, it's called an *area process* or *neighborhood process*. As with point processing, you sequentially scan the image, but rather than using the values of individual pixels, you use the values from each pixel and its neighbors.

Convolution is a powerful area process that can be used to sharpen, blur, and modify images. As you scan the image, each pixel and the pixels in its immediate neighborhood are weighted (i.e., multiplied by a value), and the new (output) pixel value is the sum of these weighted pixels. The set of weights is called the *kernel*. If the kernel k is of size $m \times n$, and $p(x,y)$ contains the pixel

continued

Imaging Tools

A minimum set of hardware for imaging and graphics consists of a camera or scanner, image-acquisition hardware, a frame buffer and CRT monitor for displaying images, and a computer for processing the images. The camera or scanner must be matched to the image-acquisition hardware. The image-acquisition hardware is often built into the frame buffer and usually accepts a standard RS-170 video signal. Some kinds of home video equipment generate standard RS-170 signals, but some generate a modulated signal that must be converted to RS-170. For better-quality pictures, try an inexpensive surveillance camera.

A frame buffer (or frame store) is special memory that stores one or more images and sequentially scans the image's pixel values to generate a video signal for the monitor. The frame buffer is also read from and written to by your computer. For the operations I describe, the frame buffer should store at least 6 bits per pixel (8 bits are preferable). For most of the pictures in this article, I used 8-bit frame buffers and image processors from Imaging Technology, Inc. (Woburn, MA). A "super VGA" with 256 colors or a Macintosh II with an 8-bit display is good for screen output, but you need additional hardware if you want to acquire images from a camera or a scanner.

Two common features on frame buffers are overlay memory and output lookup tables (LUTs), or palettes. Overlay memory provides additional bits for each pixel and is used to display graphics "over" the image, without disturbing the image. An LUT is a small memory element. Pixel values address this memory, and the LUT output is the value in the addressed memory location.

Three output LUTs are used to translate pixel intensity values into red, green, and blue values for the monitor. This allows you to add color to your images or to change the pixel intensity values. On frame buffers with overlays, the overlay memory can also drive the LUTs to allow colored overlays. Some of the operations that I describe are easier to do with the addition of overlays and output LUTs, but there are other (albeit slower) ways to do the operations if you don't have this hardware.

Image processing requires a great deal of computation. For your purposes and for many applications, a good personal computer is fine, if a bit slow on some operations. You will also need a mouse or some other pointing device.

The SIMPP Software

The Simple Image Processing Package (SIMPP) software is a simple program for learning about image processing. I added routines for image editing to SIMPP (see "Introduction to Image Processing Algorithms," March 1987 BYTE) and called it SIMPP2. SIMPP2 is written in C and requires a compiler that supports floating-point arithmetic.

A fair amount of programming is required to use SIMPP2. If you don't care to do this, there are excellent commercial programs that do much of what is described in this article. For the Macintosh II, there is Digital Darkroom from Silicon Beach Software (San Diego, CA) and ImageStudio from Letraset (Paramus, NJ). For the IBM PC AT, there is SnapShot from Aldus (Seattle, WA). You still might look at SIMPP2 to understand how some of these operations are done. I also recommend *Beyond Photography: The Digital Darkroom* by Gerald J. Holzmann (Prentice-Hall, 1988). Holzmann's book contains a good introduction to image editing, examples of edited images, and software for interactive image editing.

Table A shows some of the SIMPP2 routines. You must write the nine interface routines that connect the SIMPP2 software to your hardware.

The `acquire()` routine puts an image into the frame buffer, usually from a video camera. If you can't acquire images, read them from a disk file. The `write_LUT()` routine puts a value into an LUT. If you don't have LUTs, you might use `ptransform()` to permanently change the pixel values. The `write_over()` routine writes a value into the overlay memory, and `read_over()` reads values from this memory.

Writing an overlay value of 0 turns off the overlay at that point. You can simulate overlays by inverting the overlaid image points and then inverting the points again to remove the overlay. As an alternative, you could use 1 bit of each pixel as an overlay if you have output LUTs.

Table A: *The SIMPP2 routines used in this article. The arguments* x,y *specify the start of an image area to process, and* dx,dy *specify its size.*

IMAGE-EDITING ROUTINES

Interface routines	
`sim_open()`	Opens and initializes the frame buffer and mouse.
`sim_close()`	Closes the frame-buffer access.
`acquire()`	Puts an image from a camera into the frame buffer.
`write_LUT(color,loc,val)`	Sets the location, `loc`, in the LUT specified by color (red, green, or blue) to value `val`.
`write_over(x,y,v)`	Set the overlay memory at location *x,y* to value *v*.
`read_over(x,y)`	Returns the value of the overlay memory at location *x,y*.
`write_pixel(x,y,v)`	Writes a pixel of value *v* into frame-buffer location *x,y*.
`read_pixel(x,y)`	Returns the value of the pixel at location *x,y* in the frame buffer.
`read_mouse(&x,&y)`	Returns the location of the mouse in *x,y* and the status of the button(s).
Primitive operations	
`copy_area(x,y,dx,dy,xd,yd, dxd,dyd)`	Copies the image area starting at *x,y* and of size *dx,dy* into the destination area starting at *xd,yd* and of size *dxd,dyd*.
`cross_over(x,y,v)`	Puts a cross-hair cursor in the overlay memory.
`box_over(x,y,xe,ye,v)`	Draws a box with corner coordinates *x,y* and *xe,ye* in overlay color *v*.
`get_box(&x,&y,&dx,&dy)`	Fetches the coordinates of a rectangular area using the mouse.
Point processing	
`ptransform(x,y,dx,dy,t)`	Transforms the area using transformation table *t*.
`rgb_to_his(r,g,b,&h,&i,&s)`	Converts an RGB triple into a hue-intensity-saturation (HIS) triple.
`his_to_rgb(h,i,s,&r,&g,&b)`	Converts an HIS triple into an RGB triple.
Area processing	
`convolve(x,y,dx,dy,m,n, kernel,output)`	Convolves the image area with a kernel of size *m,n* and specified by array *kernel*. The *output* argument controls the treatment of negative convolution values.
`median3(x,y,dx,dy)`	Performs a 3-by-3 median filter on the area starting at *x,y* and of size *dx,dy*.
Geometric operations	
`rotate(x,y,dx,dy)`	Rotates the image area clockwise by 90 degrees.
`stretch(x,y,dx,dy,xsf,ysf)`	Stretches the image area by *xsf* and *ysf*.
`bwarp4(x,y,dx,dy,u,v,method)`	Warp area into area specified by arrays *u* and *v*. If *method* = 0 use nearest-neighbor interpolation, else use bilinear interpolation.
`gridwarp(x,y,dx,dy, xdest, ydest, dxgrid,dygrid)`	Use `bwarp4` to "rubber sheet" warp the source area (*x,y,dx,dy*) to a destination area (*xdest,ydest*) of the same size. Control points are spaced by *dxgrid* in *x* and *dygrid* in *y*.

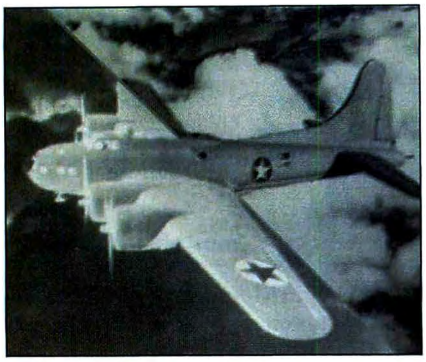


Photo 1: *Conditional point processing converts the image below the diagonal to a negative.*

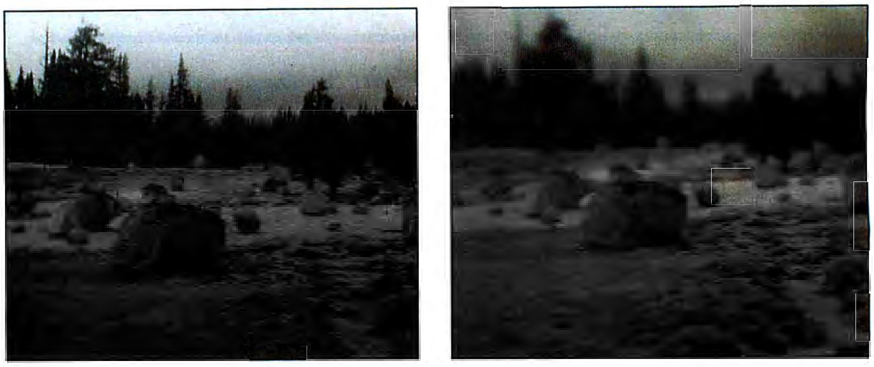


Photo 2: *Creating a fog effect. Left: The original image of a mountain meadow. Right: The same image sharpened at the bottom and blurred toward the top of the image to give the effect of fog.*

Photo 3: *The airplane in photo 1, cut and pasted. The one on the left is not blended into the background; the ones on the right are.*

values, then convolution can be expressed as follows:

$$p(x,y)=\sum_{i=0}^{m}\ \sum_{j=0}^{n} p(x+j,y+i)k(j,i)$$

Different operations are implemented by choosing different kernel sizes and values for the weights. (See "Introduction to Image Processing Algorithms," March 1987 BYTE, for more details on convolution and the choice of kernels.) A Laplacian kernel of

$$\begin{array}{rrr} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{array}$$

generates large output values only when the image intensity changes. These changes occur at object edges, so Laplacian convolution amplifies image edges.

Negative values in the kernel mean that the output of the convolution operation could be negative. While mathematically correct, negative pixel intensity is physically meaningless. You often clip negative values to 0 or take the absolute value of the output to remove these negative values.

While mathematically correct, negative pixel intensity is meaningless.

Adding the Laplacian convolved image to the original image boosts the edges in the image, making it appear sharper. You can do this in one convolution step by changing the 8 in the sample kernel to a 9. In photo 2, an image of a meadow is shown at left. In the photo on the right, I changed the ratio between the Laplacian edge image and the original image to vary the amount of image sharpening. At the bottom of the photo, the ratio is equal (i.e., the kernel center point is 9) for maximum sharpening. The Laplacian contribution, and hence the sharpening, decreases in steps going up from the bottom of the image. Above the center of the image, I started using convolution kernels that cause blurring. The effect is to add fog to a clear original.

To blur an image, you use convolution to average the pixel values in the scanned neighborhood. For example, a kernel of

$$\begin{array}{ccc} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{array}$$

sums the pixels in the neighborhood. Dividing this convolution's output by 9 gives the average pixel intensity in the neighborhood. This smooths (or blurs) the image intensities. The larger the neighborhood used in averaging, the more blurring. Other kernels modify images in interesting ways, and I encourage you to experiment.

If the area process outputs pixels within the processing neighborhood, then processed pixels will contaminate the input to the transformation. You can solve this problem by ensuring that the output (destination) image doesn't overlap the input (source) image or by buffering the output. Another problem with area processes is what to do at the edges of the image, where the kernel would be partly off the image. The usual solution is simply to scan that part of the image where the kernel is entirely inside the image.

Nonlinear area processes (convolution is a linear process) are also useful for image editing. A *median filter* is nonlinear and is good for removing noise in an image. A median filter sorts the pixels in the neighborhood by value and outputs the median value—the value in the middle position of the sorted values. Image noise tends to have a different intensity from that of neighboring pixels, so the median filter replaces it with an intensity value closer to the average.

Cutting and Pasting

A frequent image-editing operation is to cut out a section of an image and paste it somewhere else. Listing 3 shows how this might be interactively done. The `copy_area()` function allows the source and destination to be different sizes. If the paste operation is fast, you can use the source as a "brush" to paint with.

Photo 3 shows cutting and multiple pasting. You can see a number of problems with this simple approach. The most obvious is that the edges of the pasted image do not blend smoothly into the background image (the airplane on

Photo 4: *An example of cut-and-paste. Left: The original image. Center: A mask is drawn over the man's image and is used to guide the pasting. Right: The man is removed by pasting another area of the image into the mask area and smoothing the edges and texture. (Photos courtesy of Dr. Peter Burt, Advanced Image Processing Research Group, David Sarnoff Research Center)*

the left). The human eye (much like Laplacian convolution) is very sensitive to local changes in intensity.

The paste looks more natural if its edges are smoothed or blended into the background. Convolution provides one way to do this. I used a blurring kernel (e.g., all 1's) and moved it around the edge of the pasted area (the airplanes on the right) to blend in the cut images.

If the object in the source image is not rectangular, cutting around the object removes source background pixels that would look out of place in the pasted image. The blending operation now must follow the curve of the cut-out object.

If the lighting direction is significantly different on the source and destination areas, then the pasted image will look strange. Changing image lighting, shadows, and shading requires knowledge about the objects in the image and a good bit of work. Sometimes a simple brightness adjustment can make the pasted object look right in the destination image.

A pasted object with a different color or texture pattern than the background may also look out of place. Blending colors between the pasted object and the background may introduce new and unwanted colors. Sometimes, you can blend texture by smoothing at different spatial resolutions.

The three images in photo 4 are skillful examples of cutting and pasting. The mask in the center photo is drawn around the man in the photo at left. The image areas around the masked area are blended with the masked area, as well as with an image cut from an area immediately to the right of the man. This blending is complex but essentially uses many different sizes (i.e., scales) of blurring filters. This process removes spurious edges between the pasted area and the background and provides a smooth texture transition. In this example, the colors and lighting of the cut-and-pasted areas match, so these are not a problem. The man in the photo at left has disappeared in the photo on the right.

Photo 5: *In this enlargement of a face, the left half was enlarged using nearest-neighbor interpolation, and the right half by a smoother (bilinear) interpolation.*

Photo 6: *The result of enlargement (mapping) is a function of the source-image* x *address.*

Geometric Operations

Geometric operations use equations or rules to map source-image pixels to new positions in the destination image. Geometric operations include image translation, rotation, size change, and warping. Some geometric operations are similar to those used in computer graphics and may be familiar to you.

Mapping images causes problems because of the discrete nature of pixels. Consider changing the x and y scale (size) of an image area by *xfac,yfac*. Then, $xdest = x \times xfac$ and $ydest = y \times yfac$. As the source image is scanned, x and y take on discrete integer values. If $xfac = yfac = 2$, then only even destination addresses (*xdest,ydest*) are generated. Source-pixel values are mapped to every other destination address, and the output image is full of holes. If *xfac* or *yfac* is less than 1, then *xdest,ydest* will be fractional values, and more than one source pixel can map to the same destination point. This is better than holes, but it can still be a problem. Two tricks reduce these problems.

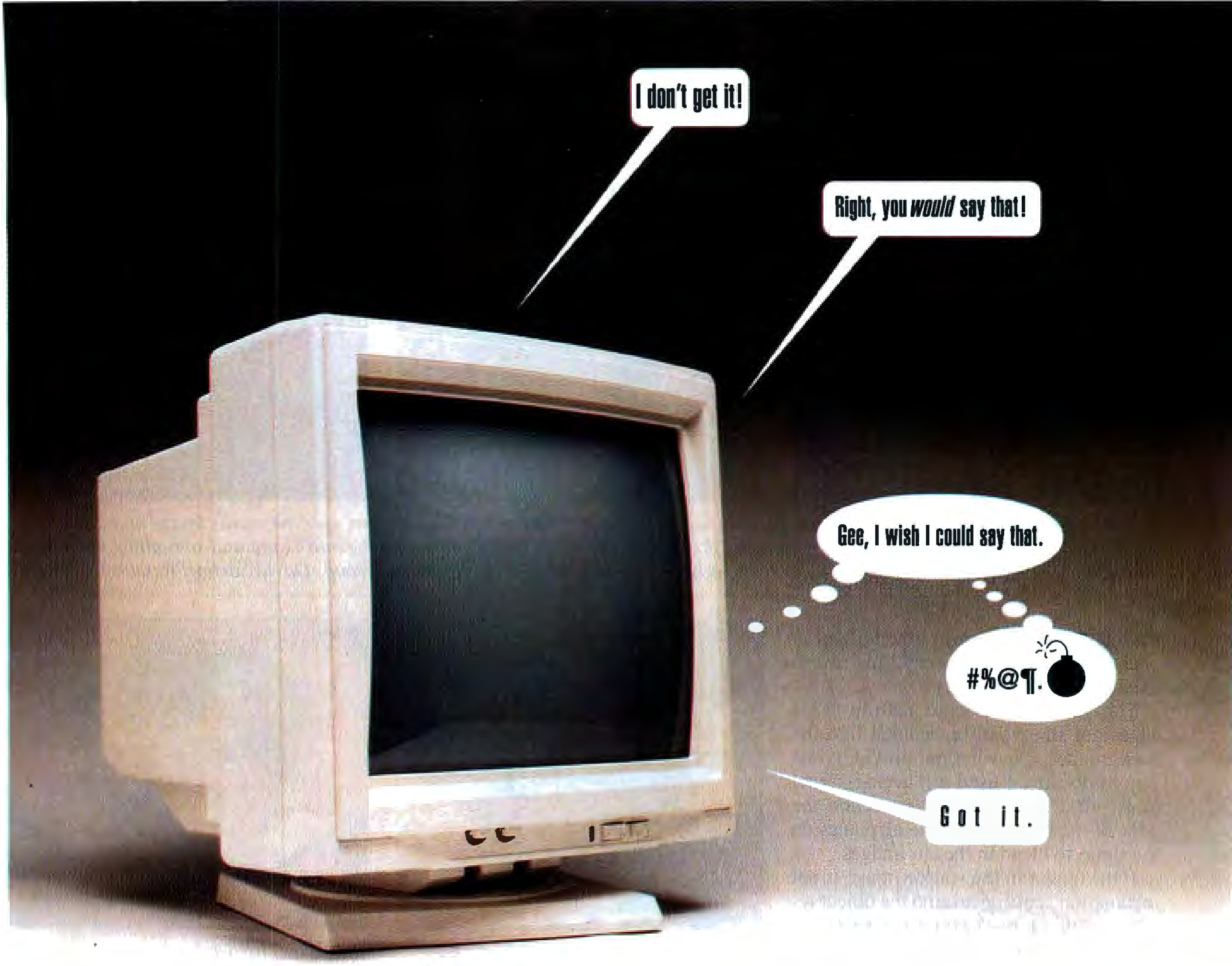
First, invert the equations and scan the destination image.

$$x = xdest/xfac$$
$$y = ydest/yfac$$

Then loop through all integer *xdest* and *ydest* values in the destination image, using these values in the above equations to specify where the source image pixel (x,y) comes from. This guarantees that all destination points will be filled.

When x and y addresses are fractional addresses, a second trick is to approximate or interpolate a source-pixel intensity based on these fractional values. "Nearest-neighbor" interpolation simply fetches the pixel value located at the integer address nearest to the fractional x and y address. This is fast but produces a blocky-looking image. Interpolations

continued



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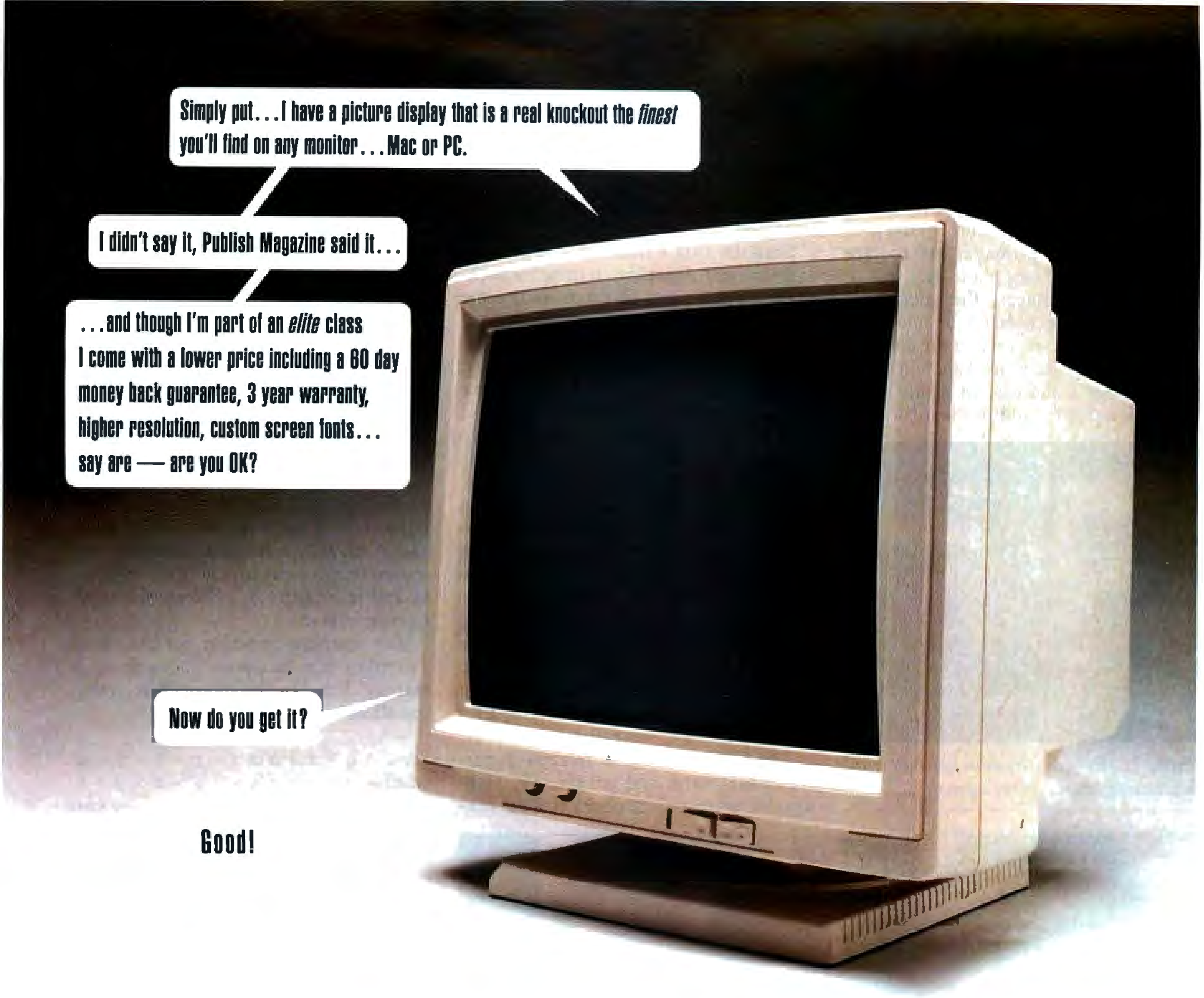

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that use the weighted sum of pixels surrounding the addressed source point produce better-looking images but require more computation (see photo 5).

With digital images, the geometric-mapping operation need not be smooth or analytic. In photo 6, I made the enlargement-mapping equation a function of the source-image x address. In photo 7, the destination-pixel y address is a function of the source y address and the pixel's intensity.

Photo 7: *The* y *destination address is a function of source-pixel intensity.*

Smooth distortions of images are called *warps*. Warping an image stretches or squeezes it to fit (map onto) some shape or surface. Image warping is typically used to remove the distortions introduced by perspective, camera optics, and so forth, but it can just as easily be used to introduce interesting distortions.

In photo 8, the picture at left shows an image before warping. The small blue squares that make up the grid are control points. Think of this image as printed on a rubber sheet with handles attached to each control point. When you move a control point with the mouse, the image point below it moves, and the surrounding image area warps (i.e., stretches and squeezes) to smoothly follow the image point. In the center photo, I made some cosmetic changes to the image in the photo at left. In the photo at right, I set the warp factor to surrealistic mode.

The SIMPP2 routine `bwarp4()` performs this warp, and `gridwarp()` manages the warp and the position of the control points. The `gridwarp()` routine first copies the source image to the destination image and overlays the destination image with the control points. The source image is divided into rectangles that match the initial position of the control points.

When a control point is moved, only the four polygons that share this control point as a vertex are updated. To do this, scan the four source-image rectangles that correspond to these polygons. In this case, scanning the source rather than the destination is simpler to understand and implement. To prevent holes in the destination image, you need to oversample the source image at fractional pixel addresses and interpolate to generate the pixel intensity value.

The warping function performed in `bwarp4()` is a four-point, bilinear warp that is defined by the following mapping equations:

$$xdest = a \times x + b \times y + c \times x \times y + d$$
$$ydest = e \times x + f \times y + g \times x \times y + h$$

continued

Photo 8: *An example of warping. Left: The original unwarped image; the blue squares are the control points. Center: The image is smoothly warped to match the edges of the polygons defined by the control points; there are minor changes to the head, jaw, and ear. Right: This image is truly warped, giving a surrealistic effect.*

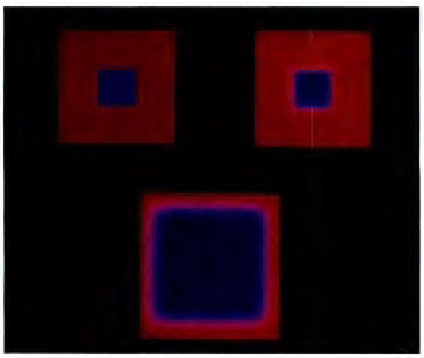

Photo 9: *An example of convolution. When a color image (upper left) is convolved to blur its edges, spurious colors may appear (upper right and, enlarged, below).*

Photo 10: *An example of sharpening. Left: The original image of flowers. Right: The sharpened image. The original image was converted to hue-intensity-saturation space; the I component was sharpened and then converted back to RGB space. (Photos courtesy of Scott Kay, Data Translation)*

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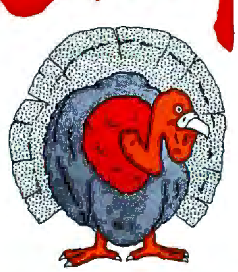

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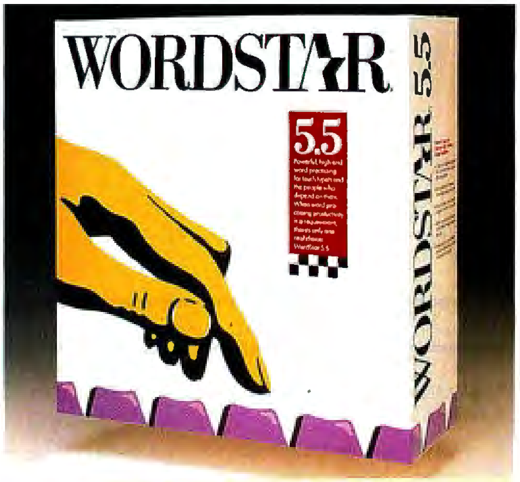

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Listing 1: *A C code fragment that makes a negative image using a point process.*

```
/* Make all pixels below the diagonal into their negative. Frame buffer is of size
XSIZE,YSIZE, and pixels have a maximum possible value of MAXPIX */

for (y = 0 ; y < YSIZE ; y++) {
   for (x = 0 ; x < XSIZE ; x++) {
      if (y > x) write_pixel(x,y, MAXPIX-read_pixel(x,y));
   }
}
```

Listing 2: *A C code fragment that interactively changes image brightness.*

```
/* Interactively change image brightness. Assumes 8-bit pixels and three output LUTs
(one each for RED, GREEN, and BLUE. */

/* Start with a "linear" LUT -- does not change pixel values */
   for (z = 0 ; z < 256 ; z++) {
         write_LUT(RED,z,z); write_LUT(GREEN,z,z);
         write_LUT(BLUE,z,z);
      }
/* Wait until all mouse buttons are up (off) */
   while (read_mouse(&x,&y)) ;
/* Loop reading mouse x position as the "brightness" control. Exit when a mouse
button is pressed */
   while (!read_mouse(&x,&y)){
      for (z = 0 ; z < 256 ; z++) {
            i = z+x;
         if (i<0) i=0;
            if (i>255) i=255;
            write_LUT(RED,z,i);
            write_LUT(GREEN,z,i);
            write_LUT(BLUE,z,i);
      }
   }
```

Listing 3: *Cutting and pasting an image in C.*

```
/* Interactive image copy (cut and paste) */

  get_box(&sx,&sy,&sdx,&sdy);  /* Get source */
  get_box(&dx,&dy,&ddx,&ddy);  /* Get destination */
  copy_area(sx,sy,sdx,sdy,dx,dy,ddx,ddy);  /* Copy area */

/****** Fragment of the get_box() subroutine ******/

  while (read_mouse(&x,&y)) ;      /* Buttons off? */
/* Put up a cross-hair overlay and use the mouse to move it */
  oldx = XSIZE/2;     /* Initialize tracking at */
  oldy = YSIZE/2;     /*  the screen center */
  cross_over(oldx,oldy,1);         /* Put up initial cross hair */
  while (!read_mouse(&x,&y)) {
    cross_over(oldx,oldy,0);       /* Erase old cursor */
    cross_over(x,y,1);            /* New cursor */
    oldx = x; oldy = y;            /* New position */
  }
  i = oldx; j = oldy;              /* Save corner position */
  cross_over(i,j,0);               /* Cross hair off */
  while (read_mouse(&x,&y)) ;      /* Buttons off? */

/* Put up a box and use mouse to change its size */
  oldx += 5; oldy += 5;            /* Start with a small box */
  box_over(i,j,oldx,oldy,1);       /* Put up initial box */
  while (!read_mouse(&x,&y)) {
    box_over(i,j,oldx,oldy,0);     /* Erase old box */
    box_over(i,j,x,y,1);           /* New box */
    oldx = x; oldy = y;            /* New position */
  }
  box_over(i,j,oldx,oldy,0);       /* Remove box */

/* i,j, oldx,oldy are now the corner coordinates */
```

The values for the equations' coefficients (a, b, c, d, and e, f, g, h) are determined from the positions of the corners of the source rectangle and the corners of the destination polygon. The coefficients are computed for each polygon updated. Listing 4 is a simplified version of bwarp4() that maps a square located at (0,0) of size 100 by 100 pixels to an interesting destination shape, using nearest-neighbor interpolation. The bwarp4() code uses a more efficient algorithm and a smoother interpolation.

Color Image Processing

Color images are usually represented by arrays of pixels with red, green, and blue values. This might be done with three separate frame buffers or with a frame buffer that had pixels containing red, green, and blue bits.

Suppose you edit a color image by adding a blue square to a red background. If you try to blend the square into the background using convolution methods, a purple fringe can appear in the image (see photo 9). Convolution averages the pixel information in an area, and combining red and blue pixels yields purple. Sharpening a color image using convolution also makes unwanted colors appear.

In human vision, intensity defines object edges, and color is used as a feature that fills the areas that the intensity edges define. The trick, then, is to separate the color information from the intensity information, convolve only the intensity information, and then recombine (i.e., fill) the color information with the intensity information. This separation also makes it possible for you to edit the color information.

There are many different ways to transform an RGB image to separate its intensity and color components. The HIS transformation converts (i.e., maps) each pixel's RGB values into a new triple of values: hue, intensity, and saturation. The I component contains the image intensity, and the H and S components contain the color. You can now convolve the intensity component and manipulate object colors by changing the hue and saturation components. Then you convert the modified HIS components back into RGB components for display. In photo 10, the image at right shows the result of sharpening the intensity and changing the hue of the image on the left.

Real-World Examples

Digital image editing is extensively used in publishing and advertising design. A photo editor can digitally edit an image

continued

Listing 4: *A C code fragment demonstrating a bilinear warp.*

```
/* Source image starts at x,y location 0,0 and is 100 by 100. Destination image is
specified by the coordinates in destx[] and desty[]. These coordinates are indexed
clockwise starting at the top left vertex. */

    static int u[] = {200,328,264,200};
    static int v[] = {136,200,264,392};
    double a,b,c,d,e,f,g,h;          /* Equation coefficients */
    double x,y;                      /* X,Y index for source */
    int iy;                          /* Input image y value (integer) */
    PIXEL z;                         /* Pixel value */
    static double sdx = 100.0;       /* Source X size */
    static double sdy = 100.0;       /* Source Y size */
    double ua,va;                    /* Destination addresses */

/* Set up equation coefficients from terms in the transformation matrix */
    a = ((double)(-u[0] + u[1]))/sdx;
    b = ((double)(-u[0] + u[3]))/sdy;
    c = ((double)( u[0] - u[1] + u[2] - u[3]))/(sdx*sdy);
    d = (double)( u[0]);
    e = ((double)(-v[0] + v[1]))/sdx;
    f = ((double)(-v[0] + v[3]))/sdy;
    g = ((double)( v[0] - v[1] + v[2] - v[3]))/(sdx*sdy);
    h = (double)( v[0]);

/* Scan the rectangular source image in x and y and use the transformation equations
to place source pixel values into the destination (warped) area. Use nearest-neighbor
interpolation and simple but inefficient code */
    for (y = 0.0 ; y < sdy; y+=0.5) {
        iy = (int)y+0.5/* Nearest-neighbor interpolation */
        for (x = 0.0 ; x < sdx; x+=0.5) {
                        /* Get nearest neighbor */
            z = read_pixel((int)(x+0.5),iy);
                        /* Get destination X address */
            ua = a*x + b*y + c*x*y + d;
                        /* Get destination Y address */
            va = e*x + f*y + g*x*y + h;

            write_pixel((int)(ua+0.5),(int)(va+0.5),z);
        }
    }
```

to improve its impact and focus. For example, a newspaper editor might sharpen and blur different areas in an image of a group of people to focus your attention on the people discussed in an accompanying article. You can see how less honest and more creative edits are possible. For examples of creative (and sometimes bizarre) image editing, look at the supermarket tabloids.

High-performance simulators are an impressive example of image editing. Simulators often use a large database of natural images to generate a background image or *gaming field*. For flight simulators, graphics of the cockpit, other aircraft, obstructions, and so forth are combined with gaming-field images to give a realistic simulation.

With a reasonably small investment in time and equipment, you can experiment with digital image editing and perhaps discover a new application. You can edit images without knowing much about image processing, but some understanding helps you get the results you want. ■

Editor's note: *The listings from this article and the* rgb_to_his() *and* his_to_rgb() *routines are available from BYTE on disk and in print.* *See page 5 for details.* *The complete SIMPP2 routines and documentation are available from Electronic Media, 89 Overbrook Dr., Wellesley, MA 02181, for $25 ($35 U.S. overseas). The SIMPP2 routines for* rgb_to_his() *and* his_to_rgb() *are based on code provided by Scott Kay of Data Translation.*

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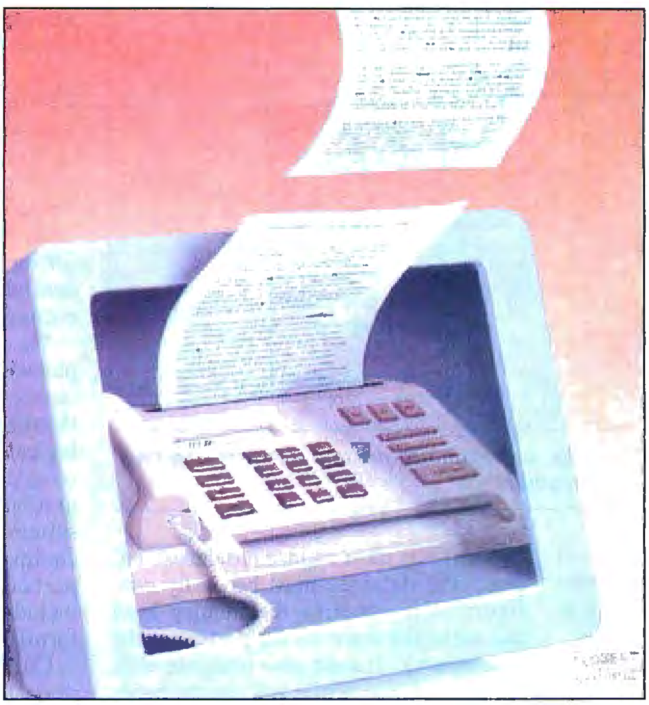
The dream—and the reality—of voice/document delivery from off-the-shelf hardware and software

Ira Scherr



Often, when I'm sitting in my office after 5:00 p.m., after having spent the day in meetings or on the road, I have to get my paperwork ready for the next day's round of meetings. That's when I wish I could pick up the phone, just like ordering a pizza, and say, "Send me all the documents from the January 4th Peterson meeting."

During the past two years there has been a remarkable evolution in products and software, bringing a great deal of fictional "future think" into focus. So, while waiting in the office for a pizza to be delivered at 7:00 p.m. one rainy evening, I dreamed of building just such an automated document-delivery system from currently available off-the-shelf hardware and software.

The script for such a system is simple. You pick up your desk phone and dial the database server. Using voice recognition and Touch-Tone detection, you communicate with the database. It responds with prerecorded (digitized) voice instruction prompts and text-to-speech conversion of the ASCII database information. You zero in on the specific documents that you need and order them after verbally entering an access code and client-billing number. The database requests the files from the document-storage server, which decompresses the compressed-image files and forwards them to the fax server. The fax server dials the fax machine on your desk and delivers the documents a few moments later in PostScript-quality output.

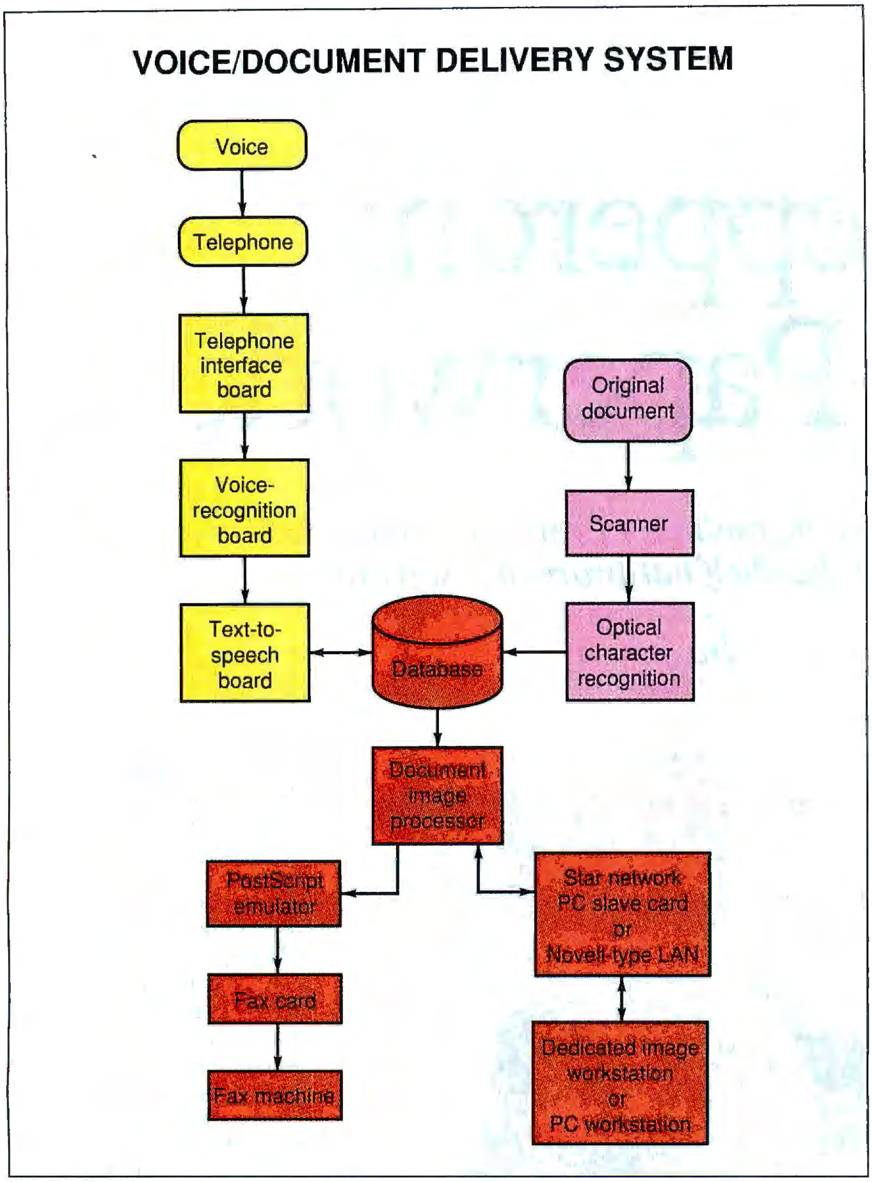
Form and Function

What would such a system look like? The figure suggests a direct path from desk telephone to voice server. What are the constructs of the voice server? It must answer the telephone and interpret signals such as tip-and-ring and Touch-Tone. And most phone boards also handle voice prompting and canned voice in the form of digitized or synthesized speech. They must also perform A/D and D/A conversions, translating analog voice over the phone to digits (0s and 1s), and then repeating the process in reverse, converting prerecorded voice files into understandable speech.

Next, the system must handle voice recognition, which can be divided into three distinct engine categories: under 100 words, from 1000 to 5000 words, and 20,000 words or over (i.e., a large vocabulary). Since voice recognition works by matching voice images on file with each live utterance, the smaller the vocabulary, the more successful the recognition.

Due to the bandwidth of the telephone and normal phone distortion, it makes sense to restrict the vocabulary to the

continued



Appropriate voice, speech, optical, image, and fax hardware and software combine to provide verbal document-retrieval capability.

smallest possible size: the numbers 0 through 9 and the words *yes* and *no* constitute the 12-word vocabulary used to power this system.

Then, the voice server needs a text-to-speech module so the database can respond to you over the phone. The hardware requirements for text-to-speech conversion are simple. While there has been a great deal of massaging of the text-to-speech algorithms and exception tables to make the speech understandable, the resulting voice still has a nasal quality and sounds like a computer with a cold. Although strange at first, the speech is accurate and understandable when you get used to the voice.

Next, you must choose a database engine. The database must be easily configurable to simplify the inquiry level and make the voice-server portion of the system work. It must also integrate with the image files. While you can probably use your favorite database, in my office we chose engines that work on several platforms across microcomputers and minicomputers. Once you have built your database, and the volume of images and data stored on the system has grown, reorganizing your database will be a monumental task. With a database that runs on several platforms, your hardware configuration can grow, and you can port your database information upward.

The document server is the heart of the system, and you need rapid input, effective interfacing with the database, and rapid output. In my office, we opted for an image-engine toolkit, although a fully configured image engine would work just as well.

The toolkit approach lets you build your own knowledge base of image-storage and retrieval capabilities, which is more useful for building systems on your own in the future. It doesn't lock you into specific hardware; it allows you to control the integration of scanning, display, and printing hardware.

As the database grows, it becomes more useful, and its use and throughput grow as well. As this activity increases, you may need to upgrade your hardware. In addition, attached to the document server is an optical disk subsystem with large-to-enormous storage capacity.

Finally, you need a fax server. This is one area that has shown remarkable growth and vitality. Fax has become a cultural add-on almost overnight. Here you have your choice of some really quality hardware and software products that produce crisp, clear, PostScript-quality output at the desktop fax-machine end.

Choosing a System

This all sounds wonderful, but is it real? In my office, we have put together a voice/document delivery system (VDDS) based on this design. It works, and because it does, I'll describe our choices for hardware and software, the reasons behind them, and some of our experiences on the way.

We chose an AT-based platform to implement our VDDS because of the sheer number and variety of boards available, thanks to open architecture. This was a logical starting point for reasons of economy, development time, and ease of integration. To speed implementation, the system runs under DOS, still the most-common accepted standard. However, part of our reasoning in selecting vendors included the operating systems and platforms driving their own growth.

Currently, we are migrating many applications to run on 80386 machines under Unix. The Unix connection provides us with the experience necessary to migrate toward more sophisticated platforms, such as DEC workstations under Ultrix, Hewlett-Packard workstations, and others.

A final consideration was one of language. Wherever possible, we have migrated to hardware vendors whose software drivers are written in C or assembly

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language. C's portability offers us an opportunity to rewrite and port this hardware over to other platforms or to link hardware and peripherals with our software drivers. In addition, the market-driven power behind C has increased the number of utilities, add-ons, and support tools available.

The hardware platform we chose was a Compaq Deskpro 386 running at 25 MHz with 4 megabytes of memory. This machine offers us speed, economy, and reliability. Our operating system is presently Compaq DOS 3.31, which allows us to break the 32-megabyte file barrier. Migration to Unix is also available on the Compaq.

Building the Voice Server

The first task in building a voice server is to open a connection between the phone system and the computer system. We chose Dialogic's D/41B multiline communications system, a board that handles all our telephone interface needs. The D/41B can detect and generate telephone Touch-Tones, as well as perform the A/D conversion needed for recording and playing back speech.

Dialogic includes a source code C language library with its boards. It has recently added Unix drivers to its software arsenal. My office uses a special home-grown SCO (for The Santa Cruz Operation) Xenix driver implementation on the Dialogic board. Thus, to remain consistent, we will probably continue to use our own drivers. Since the D/41B also handles outbound calls, it can perform call-backs during peak-activity times and mail documents accompanied by an automatic voice-mail message.

The D/41B board allows us to connect directly to a VPC 1000 voice-recognition board from Voice Processing Corp. that handles the required 0-through-9, yes-and-no vocabulary with a remarkable 97 percent accuracy. The occasional recognition failure is usually with a female voice. Since voice-recognition mirrors Touch-Tone entry, recognition problems allow us to fall back to Touch-Tone communication, with a voice prompt so informing the user.

You need a lot of power to run voice recognition. The VPC 1000 has an 80386 chip, 1 megabyte of memory, and a digital signal processor chip on-board. While the D/41B has four telephone channels on each board, we dedicate one voice-recognition board per channel at present so that each caller receives a positive response. In the future, we plan to use the DSP's speed as well as the board as a whole to multiplex four voice channels to a single VPC 1000 board. This plan is economical in both cost and slot count.

Text-to-speech technology can electronically transform ASCII text into a human-sounding voice. Its success is usually judged by the naturalness and level of intelligibility that the generated voice portrays. You can often tweak the output somewhat for specific vocabularies with the help of an exception table. But the output of even the better speech-synthesis systems still sounds like a computer voice with a cold.

The key word here, however, is intelligibility. The Speech Plus Prose 4000 voice module board that we use produces excellent synthesized speech but takes a few minutes to get used to. While short utterances can be tuned to sound remarkably lifelike, you soon become acquainted with the special lilt of the computer's synthesized dialogue when it attempts a longer speech.

Selecting a Server

Choosing a database engine is an interesting exercise. While you could probably use a standard microcomputer database such as dBASE III or IV, FoxBASE, or Paradox, we decided to use Unify Corp.'s Unify database because it offers strong fourth-generation language and Structured Query Language support. The Unify products are fully compatible over a wide range of hardware platforms ranging from microcomputers to superminicomputers running under Unix. Furthermore, the C language interface allows us to integrate our other systems' features with the database.

As the size of the document file grows, the care and feeding of the database engine become all-important. The key to offering a consistent user interface to the system lies in the way the filename for each image or document is structured, as well as in the relationship of the descriptive fields of each record in the database. Wherever possible, naming conventions should be intuitive; it quickly becomes tiresome to have to look up names in cumbersome printouts or on inquiry screens.

The Most Important Choice

Because the document image processing (DIP) engine is the heart of the VDDS, choosing an engine was very difficult. We could have chosen a ready-made bundled engine, such as the Optical Filing System from GeneSys Data Technologies for our DOS machines, Image-Server 200 from Document Technologies for Unix, or ImageSystem from Image Business Systems with its excellent scanning conventions. All work as stand-alone servers and would integrate easily.

For this product, however, we decided to go with the KIPP Image Processing Platform Developer's Toolkit from KoFax Image Products (see "The Paperless Office," July BYTE). The new KIPP Developer's Toolkit offers a fast way of getting up and running painlessly. KoFax upgraded its technology with new hardware and software releases this fall. While the document server runs under DOS, KoFax has upgraded its software to run under Microsoft Windows, which is fast becoming a standard.

The KoFax technical staff is porting the software to run under Xenix/Unix, which will make maximum use of 80386 (and 80486) capabilities. In the future, we expect to be able to run KIPP on such diverse engines as the IBM RT, Sun386i, and Data General machines—platforms that have AT or Micro Channel adapter slots.

The KoFax engine stores files in TIFF as well as CCITT Group 3 and 4 fax formats. It supports a wide range of scanners and printers at 150, 200, 300, and 400 dots per inch. With the KoFax board, we used the KoFax KIPP library of software utilities to speed up system development. The speed of scanning and printing to screen is important, as it has an impact on the system in a busy office and the throughput to the fax server. Screen write speed with KIPP is very impressive.

Optics Only

The imaged documents are stored on optical disk. The document-storage server allows you to use 5¼-inch and 12-inch WORM (write once, read many times) drives as well as 5¼-inch erasable optical drives. Implementing a real-life system can in fact involve mixing all three or standardizing on a single format. With the Future Domain SCSI TMC-830 host adapter, we could mix all three.

The Future Domain board arrived with software drivers for DOS, Xenix, Novell, Interactive Unix, and OS/2. To interface with the optical drives, Opti-Driver from Optisys allowed us to use an optical disk as if it were any other magnetic peripheral storage device. Opti-Driver lets us buffer to DOS memory or magnetic memory, streamlining the scanning and writing to disk.

For this application, my office chose Sony's 12-inch WORM drive (the WDD-3000 writable disk drive) and the 5¼-inch SMO-S501 magneto-optical (MO)

ITEMS DISCUSSED

Compaq Deskpro 386
Compaq Computer Corp.
20555 FM 149
Houston, TX 77070
(713) 370-0670
Inquiry 865.

D/41B multiline communications system
Dialogic Corp.
300 Littleton Rd.
Parsippany, NJ 07054
(201) 334-8450
Inquiry 866.

FaxPhone 20
IX-30F image scanner
LBP-8 Mark III R laser printer
Canon U.S.A., Inc.
One Canon Plaza
Lake Success, NY 11042
(516) 488-6700
Inquiry 867.

GammaFax CP
GammaLink Graphics Communications
2452 Embarcadero Way
Palo Alto, CA 94303
(415) 856-7421
Inquiry 868.

GoScript
LaserGo, Inc.
9369 Carroll Park Dr., Suite A
San Diego, CA 92121
(619) 450-4600
Inquiry 869.

HiJaak
Inset Systems, Inc.
71 Commerce Dr.
Brookfield, CT 06804
(203) 775-5866
Inquiry 870.

ImageSystem
Image Business Systems Corp.
140 East 45th St.
New York, NY 10017
(212) 972-4400
Inquiry 971.

ImageServer 200
Document Technologies, Inc.
2465 East Bayshore Rd.
Palo Alto, CA 94303
(415) 858-0372
Inquiry 872.

KIPP Image Processing Platform Developer's Toolkit
KoFax Image Products
3 Jenner St.
Irvine, CA 92718
(714) 727-1733
Inquiry 873.

LF 5010
Panasonic Industrial Co.
Two Panasonic Way 7F1
Secaucus, NJ 07094
(201) 392-6071
Inquiry 874.

Optical Filing System
GeneSys Data Technologies, Inc.
11350 McCormick Rd., Suite 1300
Hunt Valley, MD 21031
(301) 785-0660
Inquiry 875.

OptiDriver
Optisys, Inc.
8620 North 22nd Ave., Suite 109
Phoenix, AZ 85021
(800) 327-1271
Inquiry 876.

PC-Slave/286
Alloy Computer Products, Inc.
165 Forest St.
Marlborough, MA 01752
(508) 481-8500
Inquiry 877.

Prose 4000 voice module
Speech Plus, Inc.
1293 Anvilwood Ave.
Sunnyvale, CA 94088
(408) 745-1818
Inquiry 878.

RDSP/4232
Rhetorex, Inc.
1671 Dell Ave., Suite 208
Campbell, CA 95008
(408) 370-0881
Inquiry 879.

SMO-S501 magneto-optical erasable drive
WDD-3000 writable disk drive
WDD-600 writable disk drive
WDC-2000-10 disk drive controller
Sony Corporation of America
Sony Dr.
Park Ridge, NJ 07656
(201) 930-6025
Inquiry 880.

StarLAN 10 Network
AT&T Data Systems Group
Call your local AT&T representative for more information.
Inquiry 1176.

TMC-830 host adapter
Future Domain
1582 Parkway Loop
Tustin, CA 92680
(714) 259-0400
Inquiry 1177.

TR112 twin-channel fax card
Brooktrout Technology, Inc.
110 Cedar St.
Wellesley Hills, MA 02181
(617) 235-3026
Inquiry 1178.

Unify
Unify Corp.
3870 Rosin Court
Sacramento, CA 95834
(800) 248-6439
Inquiry 1179.

VPC 1000
Voice Processing Corp.
One Main St.
Cambridge, MA 02142
(617) 494-0100
Inquiry 1180.

erasable drive, plus the new Panasonic LF 5010 5¼-inch WORM drive. The Sony 12-inch WORM drive provides us with 3.2 gigabytes of storage per disk (Sony has also announced the WDD-600 WORM drive, which *doubles* this capacity), while the LF 5010 offers 940 megabytes per disk. Both of these companies also offer optical jukeboxes for large storage requirements.

The Sony MO erasable drive proved exceptionally easy to address as a SCSI device and looked like a magnetic drive even without a software driver. This erasable optical drive is perfect for situations where archived documents are stored at another location or where archiving is unnecessary. While the erasable medium is significantly more expensive than the WORM drive, the capability of a million erase and rewrite operations proves cost-effective very quickly.

continued

Picking Peripherals

For scanning documents through the KoFax board, we selected the Canon IX-30F image scanner, a gray-scale automatic-feed scanner that the KoFax drivers support. The gray-scale capability offers a range of document functions, including text, graphs, drawings, maps, and pictures at 300 dpi in up to 256 shades of gray. A number of software programs are available to support optical character recognition on the IX-30F. A number of other scanners also use the Canon engine.

We also needed a laser printer so we could print documents at a clerical workstation. KoFax also supports the Canon LBP-8 Mark III R laser printer, which has 300-dpi resolution and 8-page-per-minute output. This particular model prints two-sided documents and has a wide range of font and memory accessories.

The Fax Server

The heart of the fax server is the GammaFax CP board from GammaLink Graphics Communications. Bundled with special communications software, the GammaFax CP board has an on-board 80188 processor and 256K bytes of memory, thus providing an efficient background-automated fax service. Additional GammaLink software converts PostScript language files into 196-dpi fax files.

With the aid of software such as Go-Script from LaserGo (which comes bundled with HiJaak from Inset Systems), the fax server can send PostScript-quality documents. The output offers the system high-quality fax and improves the readability of all material.

Several new fax-board products have appeared that add additional automated utilities to a fax server. Some products, like the TR112 twin-channel fax card from Brooktrout Technology, offer two fax boards in one slot and may also add features that automate fax transmission. To remain consistent for hardware support and service, we chose a Canon Fax-Phone 20, because it can be used as both a phone and a fax machine. However, whatever fax hardware you currently have will also work.

Linking to the LAN

The voice server is just one access point for the document server. As a strictly voice-in/document-out system, it would scan in the documents and catalogue them at a systems manager's workstation as part of the basic DIP engine. In a

continued

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2400etc/e

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Allergic to high modem prices? Here's news that will clear your head, not your budget.

ATI® Technologies' 2400etc/*e*® external modem* meets the competition feature for feature...and then some! Remarkably, it costs just a fraction of the price.

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The 2400etc/*e* complies with the CCITT V.42 error-control standard, including LAP-M and MNP, for 100% error-free data transfer. As well as offering synchronous operation, it's fully compatible with the standard and extended Hayes® 'AT' command sets. Plus, ATI's easy-set front panel controls provide convenient access to frequently used commands.

Don't suffer from high prices. The ATI 2400etc/*e* external modem cures Hayes fever for only **$299.**** And that's nothing to sneeze at.

You'll be relieved to know that ATI also offers a high-performance internal modem, the 2400etc/*i*, at an equally non-allergic price. Only **$239.****

For more information, contact your supplier or

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Fax: (416) 756-0720

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departmental configuration, the voice server looks like a terminal on the document-delivery system.

To add departmental workstations on the system, an AT&T StarLAN 10 Network expansion board maintains a high throughput rate (10 megabytes per second). It also includes software optimized for the 80386 under DOS, as well as Unix and LAN connectivity by way of Ethernet.

Alloy Computer Products' PC-Slave/286 cards are also an economical choice, adding two workstations per card in a star network configuration. For document distribution outside the department, you can connect the VDDS to just about any PC LAN or workstation on the network.

With an upgrade path toward the new RISC servers, the growth path of the VDDS in terms of document-storage capacity and power is virtually unlimited.

Other Options

With the sheer volume of products available today, it's possible to customize the VDDS to handle a whole raft of side issues. In our system, we keep track of who placed an order and on which documents, the volume of orders, the time of day, the length of time between placing the voice order and the output, and so on. This statistical information, some of which comes out of the password-security system, can be important in spotting problems and planning for the future. It is my experience that a system like this will be used more and more as people find their way around it and develop shortcuts to the information they need.

With this system, you can mix file formats and store material prepared for WordPerfect, Microsoft Word, PageMaker, Ventura Publisher, and other files and output them to a desktop fax machine. As an alternative, you can interface a low-cost ink-jet or laser printer with a modem and use that setup instead of the fax. The VDDS is designed as a series of stand-alone modules. Thus, you can add a voice server to an existing or planned DIP and a fax server at the end of any DIP.

With the integration of DSPs into systems, many existing board sets will provide remarkable multiple functionality that will help to reduce not only board count but also cost. We have been testing a phone-interface board from Rhetorex, the RDSP/4232, which uses a Texas Instruments 32025 DSP. The on-board DSP provides significant potential for adding speech recognition and text-to-speech capabilities via algorithms in software or ROM and for eliminating the use of specific boards to perform these functions. Steve Jobs embraced this potential when he included a DSP in the NeXT computer.

A Few Steps Further

Currently, we are working on an approach in which the VDDS is but one building block in a more comprehensive information system. This system, originally designed for law firms with heavy practices in trial law, merges voice and document into a whole new dimension. It lets you store any phone conversation, phone interview, voice-phone message, or voice annotation of any document on the fly. It can take dictation and attach it to any E-mail message, vocalize E-mail, voice-forward comments or conversations to any other user, store voice or commented documents for future reference, or forward voice packets to be transcribed.

VDDS enables a hypertext-like capability between documents and permits a kind of "hyperspeak" function that appends voice comments or voice of any sort to document hypertext buttons. For ultrasecurity situations, if password protection isn't sufficient, voice security can be added: You simply say your name when logging onto the system. The voice-security board can handle up to 3000 voice masks, each mask being a person's voice speaking that person's own name.

Documents to Go

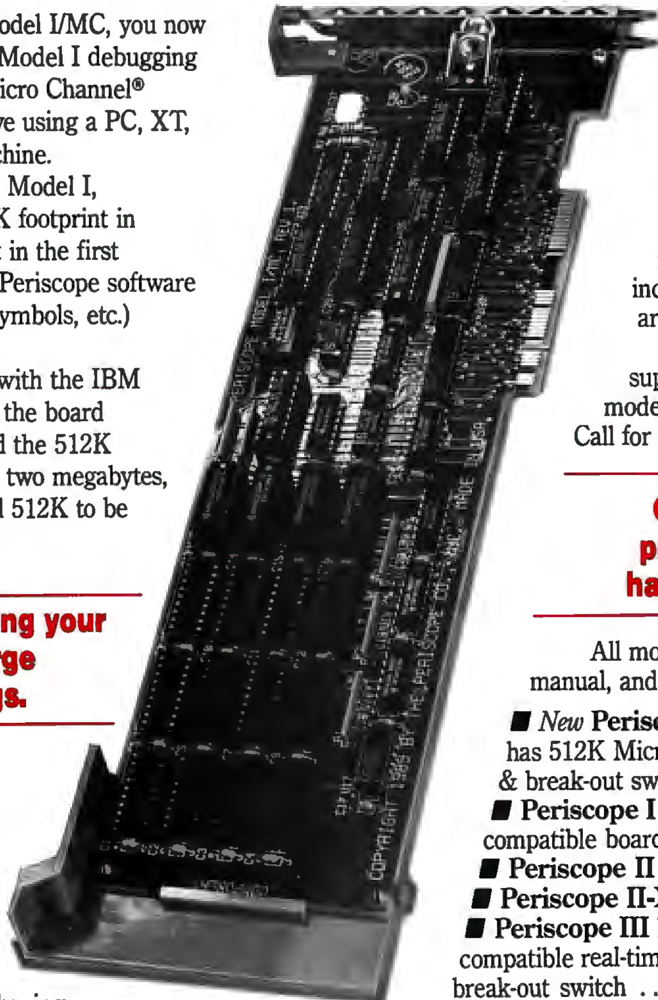
The real world has an awful lot of paper-loaded file cabinets. As data-entry techniques improve and as we learn to rely on the computer terminal instead of hard copy, maybe this mountain of paper will go down.

But even in an optimal situation, we will always need to store images of documents with legal and graphical content or to call up digital data without a screen and keyboard. By adding a voice server and a fax server to any type of system, you increase data-distribution possibilities by the millions of telephones that are currently sitting on desks everywhere, and at a minimal cost per user.

So, the next time I get back to the office after 5:00 p.m. with lots of work still to do, I think I'll just pick up the phone and order some documents along with my pepperoni and extra cheese. Can I get you anything? ■

Ira Scherr is president of Digital Voice Systems, Inc. (Bronx, NY). He has an M.A. from Columbia University and can be reached on BIX c/o "editors."

Now There's a Periscope Board for Your IBM PS/2®



With the new Periscope® Model I/MC, you now have the same robust Periscope Model I debugging capabilities using a PS/2 with Micro Channel® architecture that you already have using a PC, XT, AT, or AT-compatible 80386 machine.

Just like the current Periscope Model I, Periscope Model I/MC has a 32K footprint in system memory, above 640K but in the first megabyte. The board stores the Periscope software and all debugging information (symbols, etc.) in its write-protected RAM.

Designed for use in machines with the IBM Micro Channel bus architecture, the board allows you to add chips to extend the 512K of write-protected RAM to a full two megabytes, if need be. (Most developers find 512K to be quite enough, however.)

Don't worry about trashing your debugger, debugging large programs, or erratic bugs.

With this new board in your IBM PS/2 or compatible, Periscope uses zero memory in the lower 640K. So you don't have to worry about things like a runaway program trashing your debugger, or not being able to debug a very large program, or having bugs appear or disappear when you load your debugger.

Use the break-out switch, which plugs into the board, to break in to your system safely any time. It keeps you from having to power down and back up when your system hangs. You can just press the little red "panic" button to find out exactly what is going on.

Real-time hardware-assisted debugging of programs running on PS/2s is now possible! The remote feature of the new Version 4.3 Periscope software enables Periscope IV to support real-time debugging of programs running on DOS-based machines, including those with Micro Channel architecture. The open architecture remote debugging feature will support OS/2® and other protected-mode environments in the near future. Call for details.

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All models include Version 4.3 software, manual, and:

- *New* **Periscope I/MC** (MC Board for short) has 512K Micro Channel-compatible board & break-out switch .... $745.
- **Periscope I** has 512K PC- and AT-compatible board & break-out switch ..... $695.
- **Periscope II** has break-out switch .... $175.
- **Periscope II-X** has no hardware ...... $145.
- **Periscope III** has PC- and AT-compatible real-time board (to 10MHz) & break-out switch .... $1395.
- **Periscope IV** has 80286 and 80386 AT-compatible real-time hardware (to 25MHz) & breakout switch .... $2195-$2995.
- **PLUS** board is Model I board (no software), optional with Models III & IV ....$500.

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Periscope Model I for PCs, XTs, ATs, and AT-compatible 80386s. The manual, disk, and quick-reference card shown come with all models of Periscope.

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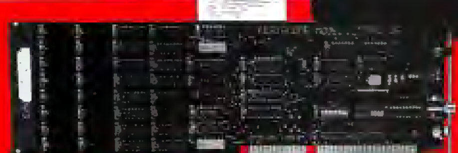

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NOTE: Pipeline Page Mode system architecture is preferred in many applications to cache design. It is faster than all but the largest cache systems in certain applications requiring substantial memory calls.

***BUYERS BEWARE!* Northgate charges credit card sales only when your system is in the shipping process. Some others use your money by charging cards at time of sale. We recommend you be aware of this when considering your vendor.

When you want to know all about a computer system ... Ask Dr. Jerry Pournelle.*

Put a machine in Pournelle's workshop. He'll soon tell you everything you want to know about it with no punches pulled.

Recently, Dr. Pournelle looked at Northgate's 80386 Pipeline Page Mode system and reported in BYTE July, 1989 (excerpted):

*Jerry Pournelle holds a doctorate in psychology and is a writer who also earns a comfortable living writing about computers present and future.

Words and Pictures

The products listed in the first section of this resource guide are PC board products that bring speech-recognition technology to your desktop. The second section deals with visual information. The hardware products listed let you perform digital image processing on your desktop.

Voice-Recognition Boards

Cherry Electrical Products
3600 Sunset Ave.
Waukegan, IL 60087
(312) 360-3500
Cherry VoiceScribe 1000 Plus $3400
Speaker-dependent voice-recognition board for DOS computers. Each user can train the system with up to 1000 words and phrases per application.
Inquiry 1181.

Dialogic Corp.
129 Littleton Rd.
Parsippany, NJ 07054
(201) 334-8450
VR/10 .... $3695
Speaker-independent voice-recognition board for use with Dialog's Dialog/4X DTMF call-processing boards; recognizes 16 words by any speaker over phone lines; works with the IBM AT and compatibles.
Inquiry 1182.

International Voice Products
14251-B Chambers Rd.
Tustin, CA 92680
(714) 544-1711
VoiceLink SRB-LC II $350
Speaker-dependent voice-recognition board for DOS computers; provides an alternative to keyboard input for applications.
Inquiry 1183.

Kurzweil Applied Intelligence, Inc.
411 Waverly Oaks Rd.
Waltham, MA 02154
(617) 893-5151
VoiceEM $18,900
Large-vocabulary speech-recognition system that automatically creates emergency medical reports; uses trigger phrases as shorthand; works with 80386-based systems or, optionally, comes with an 80386-based computer.
VoicePath $18,900
Speech-recognition system for producing medical pathology reports; features large, application-specific vocabulary and trigger phrases; runs on 80386-based systems or comes with an 80386 computer.
VoiceRAD $18,900
Speech-recognition system for producing radiology reports; features large vocabulary and trigger phrases; runs under 80386 systems or comes with an 80386 computer.
VoiceReport $12,900
Development system that lets you create customized speech-recognition applications for the Kurzweil Acoustic/Phonetic Analyzer Card; features KBEdit, a knowledge-base editor; runs on 80386-based computers.
Inquiry 1184.

MTI, Inc.
14711 Northeast 29th Place, Suite 245
Bellevue, WA 98007
(206) 881-1789
Pronounce Plus $799
Speaker-dependent speech-recognition board for DOS systems that lets you drive applications and launch custom macros under voice control; on-line capacity of 256 words and phrases.
Inquiry 1185.

Scott Instruments Corp.
1111 Willow Springs Dr.
Denton, TX 76205
(817) 387-9514
SIR Model 20 .... $1495
Speaker-independent speech-recognition system for the IBM AT and compatibles; can have up to 160 words active at once; also performs digital audio playback.
Inquiry 1186.

Spectrum Signal Processing, Inc.
3700 Gilmore Way, Suite 301
Burnaby, Canada BC V5G 4M1
(800) 663-8986
(604) 438-7266
Model μPD7763/4 PC Card $1695
Speaker-dependent speech-recognition and synthesis card with 127 active words; works with DOS computers.
Pro-Audio Interface $1850
Speech analyzer, pattern comparator, and speech synthesizer for DOS computers.
TMS320C25 Voice Processor Board $1295
Speech-processing board for DOS computers; features software development system.
Inquiry 1187.

Texas Instruments, Inc.
P.O. Box 655012, Mail Stop 57
Dallas, TX 75265
(800) 527-3500
TI-Speech Hardware $995
Speech-recognition board for DOS computers; features a dedicated 32-bit processor and 32K-byte dual-port RAM; software toolkits and telephone interface available.
Inquiry 1188.

The Voice Connection
8258 Kingslee Rd.
Bloomington, MN 55438
(612) 944-1334
IntroVoice V $495
Voice-input system for DOS computers; features 500 words or phrases per resident library.
IntroVoice VI $695
Voice I/O system for DOS computers; features 500 words or phrases per resident library and unlimited text-to-speech synthesis.
Inquiry 1189.

Voice Control Systems
14140 Midway Rd., Suite 100
Dallas, TX 75244
(214) 386-0300
TeleRec $2495
Speaker-independent voice-recognition system for DOS computers; uses discrete recognition technology.
TeleRec II $3495
Connected-speech voice-recognition system for DOS computers.
Inquiry 1190.

Votan
4487 Technology Dr.
Fremont, CA 94538
(800) 288-4756
(415) 490-7600
Voice Card $1800
Speaker-dependent continuous-speech voice-recognition system for the IBM AT and compatibles; features immunity to interference from background noise, voice output, and optional telephone interface.
Inquiry 1191.

Image-Processing Hardware

DataCube, Inc.
4 Dearborn Rd.
Peabody, MA 01960
(508) 535-6644
MaxVision AT-1 .... $9500
Image-processing subsystem for the IBM AT and compatibles; acquires, processes, and displays 512- by 512-pixel, 8-bit, gray-level images.
Inquiry 1192.

Data Translation, Inc.
100 Locke Dr.
Marlborough, MA 01752
(508) 481-3700
DT2858 .... $1695
Image coprocessing board for use with other Data Translation boards.
DT2861-60Hz $4995
Arithmetic frame grabber for the IBM AT and compatibles; features ALU, lookup tables, and 512- by 512-pixel, 8-bit, gray-scale frame stores; also available in a phase-alternate line (PAL) version.
DT2862-60Hz $2995
Arithmetic frame grabber with four frame-store buffers for the IBM AT and compatibles; features ALU, lookup tables, and four 512- by 512-pixel, 8-bit, gray-scale frame stores; PAL version also available.
DT2871-60Hz $3995
Color frame grabber for the IBM AT and compatibles; features 16.8 million colors at 512- by 512-pixel resolution; PAL version available.
QuickCapture $1995
Frame grabbers for AT- and MCA-bus systems; features include lookup tables, square pixels at 768- by 512-pixel resolution, and 8-bit gray scales; PAL version available.
Inquiry 1193.

Imaging Technology, Inc.
600 West Cummings Park
Woburn, MA 01801
(617) 938-8444
PCVISIONplus Frame Grabber $1995
Real-time video aquisition, storage, and display board for DOS computers; features 1024- by 512-pixel resolution, 8-bit buffer, square pixels, I/O lookup tables, pseudocolor display, and software support.
VISIONplus-AT Advanced Frame Grabber $7995
Two-slot, 34010-based image processor for the IBM AT and compatibles; features resolutions up to 1024 by 1024 pixels with 8 bits per pixel.
VISIONplus-AT Color Frame Grabber $3995
24-bit, 768- by 512-pixel color video frame grabber for the IBM AT and compatibles; features lookup tables, 4-bit overlays, and optional National Television System Committee/PAL decoding and encoding.
VISIONplus-AT Image Processing Accelerator $4495
32-bit floating-point processor (TI 320C30) for VISIONplus-AT products; resides in an AT slot but uses the VISIONbus.
VISIONplus-AT Overlay Frame Grabber $2395
8-bit frame grabber for the IBM AT and compatibles; provides 256 gray levels or pseudocolor display; features 768 by 512 square pixels, lookup tables, and 4 overlay bits.
Series 151 Image Processor $28,990
Image-processing subsystem with bus connections to AT, MCA, and VMEbus systems; features high-resolution acquisition, processing, and display.
VS100-AT Variable-Scan Frame Grabber $4495
Frame grabber for the IBM AT and compatibles that features a 1024- by 1024-pixel, 12-bit frame buffer; has 12-bit digital input port, feedback processor, external image acquisition trigger, and pseudocolor display.
Inquiry 1194.

IMAgraph Corp.
11 Elizabeth Dr.
Chelmsford, MA 01824
(508) 256-4624
Image 32 .... $8995
1024- by 1024-pixel, 32-bit imaging board for the IBM AT and compatibles; displays 16.7 million colors simultaneously; uses 1-megabit video RAMs.
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Matrox
1055 St. Regis
Doral, Canada QE H9P 2T4
(514) 685-2630
Matrox MVP $5495
Acquires, processes, and displays 8-bit gray-scale and 24-bit color video images; features 1024- by 1024-pixel video memory and 512- by 512-pixel display capability.
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Truevision, Inc.
7351 Shadeland Station,
Suite 100
Indianapolis, IN 46256
(317) 841-0332
ATVista $2995
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NuVista $2995
Video-capture and imaging board for the Mac II family; features the TMS 34010 graphics processor.
Targa Videographic Adapters .... from $1595
Line of five imaging boards for DOS computers; features real-time video capture, display, and genlock. Number of displayable colors varies from 256 gray levels to 16 million colors at 512 by 512 pixels.
Inquiry 1197.

Visual Information Technologies
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Plano, TX 75075
(214) 596-5600
VITec Image Computer $39,900
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Inquiry 1198.

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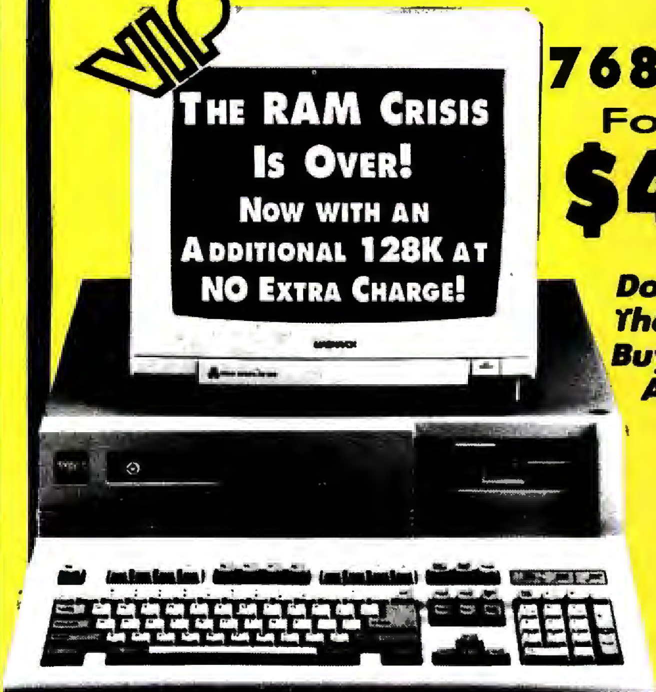

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TEN YEARS OF ROWS AND COLUMNS

From a 16K-byte VisiCalc to multimegabyte packages, spreadsheets have come a long way in a decade

Tracy Robnett Licklider

A decade ago, Bob Frankston and Dan Bricklin radically redirected personal computing when they shipped VisiCalc, the first personal computer spreadsheet program. VisiCalc transmuted the Apple II from a hobbyist's novelty into an essential tool for financial analysts. For the next 10 years, spreadsheets evolved steadily. Many technological developments occurred between the advent of VisiCalc, a pioneering program, and today's high-powered packages.

Starting Small

Frankston and Bricklin handcrafted VisiCalc in 6502 assembly language to run on a 32K-byte Apple II. (See the text box "Birthing the Visible Calculator" on page 326.) VisiCalc offered a small spreadsheet of only 254 rows by 63 columns, and its main menu was Spartan; it presented only a stark concatenation of its single-letter commands. On-line help, originally planned, had to be sacrificed to leave enough memory for spreadsheet data. The program offered only basic options for displaying cells.

Furthermore, VisiCalc did not support natural-order recalculation. Instead, it had two fixed recalculation patterns: sweeping across rows (left to right), and down columns (top to bottom). Both methods often produced vexing, unresolvable circular references. You could set the column width, but it had to be the same for all columns, and text could not span columns. In spite of these limitations, however, VisiCalc was a runaway best-seller and was rapidly ported to virtually all major 6502- and Z80-based personal computers.

Ironically, VisiCalc was not ported to the CP/M operating system until well after Sorcim seized that niche with SuperCalc. The first portable computer, the Osborne/1, had SuperCalc bundled with it. While essentially a VisiCalc clone, SuperCalc added disk-based help, column widths that could be set individually, and text that spanned columns.

Microsoft joined the spreadsheet fray with Multiplan, which provided links from spreadsheet cells to external files. It also had a recalculate-until-done command, which recalculated until no cell changed. This process offered a useful way to get around circular reference problems.

Spreadsheet software desperately needed more memory for new features and bigger spreadsheets. The decade's most significant technical development for spreadsheets was, therefore, the advent of larger-memory personal computers. The 128K-byte Apple III arrived in May 1980, and the 256K-byte IBM PC followed in August 1981. Makers of 8-bit computers engineered bank-switching schemes to reach beyond the intrinsic 64K-byte limits.

VisiCalc Advanced Version used this new memory to restore features dropped from the original. It let users transform spreadsheet results into presentable printed reports by adding cell formatting, page formatting, and printer setup commands. Indeed, spreadsheet add-on programs first emerged to satisfy printing demands. Sideways was one such package; it printed spreadsheets sideways on a printer.

In addition, VisiCalc Advanced Version introduced keyboard macros. Any sequence of keystrokes could be bound to a key as a macro, complete with pauses and points at which to prompt for and accept user input. Macros created a way to use spreadsheets to develop applications. They spawned a new software industry that packaged them for use on everything from taxes to word processing.

All Together Now

In 1981, the now-all-but-forgotten Context MBA tantalized spreadsheet users with the first integrated spreadsheet; it combined windows, graphing, word processing, file management, and a spreadsheet. Context MBA could show a spreadsheet in one window and a graph of selected cells in another. Unfortunately, its developers had implemented Context MBA in the UCSD Pascal p-code system. That made it incompatible with PC-DOS, already the dominant IBM PC operating system.

In early 1983, Apple unveiled its Lisa personal computer

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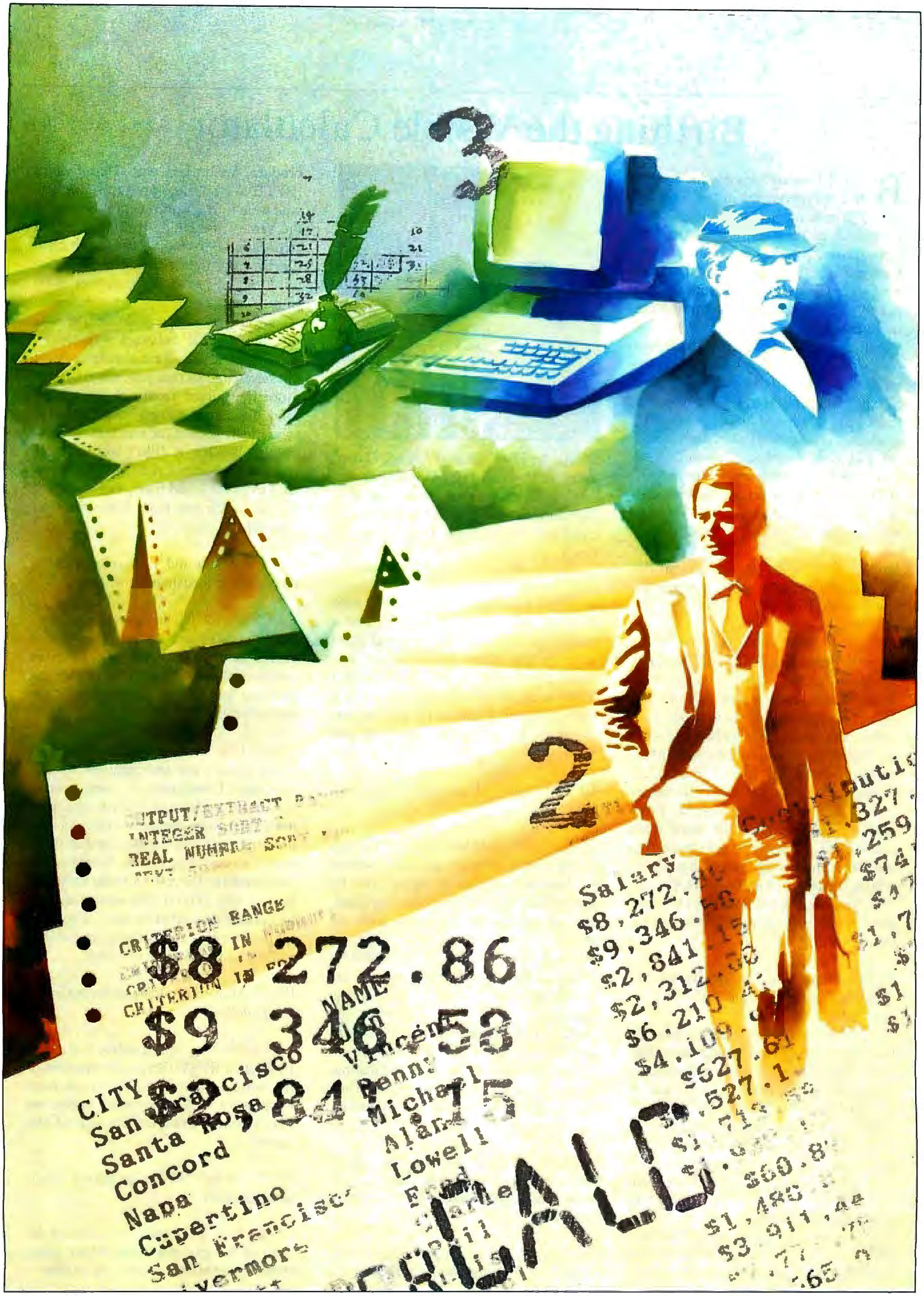

ILLUSTRATION: RUBEN DEANDA © 1989

Birthing the Visible Calculator

BYTE's first ad for a product called VisiCalc appeared in the September 1979 issue on page 51. The ad's text compared the time and effort it took to plan, project, write, estimate, calculate, revise, erase, and recalculate figures using a calculator, pencil, and paper, versus carrying out these steps by computer.

Nowadays, we take the spreadsheet for granted. But 10 years ago, there was no way to routinely tweak numbers on a personal computer until they made sense. In 1978 and 1979, two MIT graduates changed all that. Dan Bricklin and Bob Frankston created VisiCalc, the first electronic blackboard. BYTE editor Janet Barron talked with Bricklin and Frankston, the two men who started the "what-if" industry.

Photo A: *The "what-if" gang, Dan Bricklin (left) and Bob Frankston (right). Bricklin is now president of Software Gardens, and Frankston is chief scientist at Lotus Development Corp.*

BYTE: What kind of background did the two of you have before you started working on VisiCalc?

BRICKLIN: Bob and I met when I was an undergraduate at MIT and he was a graduate student. Both of us were working on the Multics project. Multics was an operating system, a derivative of which later became Unix. Bob had written BASIC for a computer called the MicroMind, and I had worked on a variety of things, such as the APL interpreter and some interactive calculators. From MIT, I went to Digital for three years and worked in computerized typesetting and word processing (screen-based text editing). I designed and wrote software, some of which later became DecMate word processing on the PDP 8, a very small machine.

BYTE: What was the motivation for your creation of VisiCalc?

BRICKLIN: After having worked a few years for a small New Hampshire company that made electronic cash registers based on microprocessors, I went to Harvard Business School. I had my calculator, ran my numbers at home at night, and when I made errors, daydreamed about "word processing" numbers so that I could recalculate them with a new assumption—say, 12 percent instead of 10 percent.

My image was based on a calculator with a mouse and a heads-up display like a fighter plane so you could see the numbers. I realized you could do it with a video screen (projection TV) and a mouse—some kind of a personal computer device. There weren't many personal computers in those days, but I knew it could be done. I decided that when I got out of school, I'd develop this electronic blackboard for numbers and try to sell it.

BYTE: How did you implement the idea?

BRICKLIN: I told Bob about it. Though many of my Harvard Business School professors were encouraging, my finance professor was very discouraging. But we decided to go ahead with the project anyway. We rented an office in the basement of a Cambridge building and used timesharing at night while Ada was being developed on the same system during the day. Bob wrote all night and went to bed in the morning. I was still going to school, and after I got home in the afternoon, I debugged, did testing, quality assurance, and whatever. Then we bought ourselves our own timesharing system.

FRANKSTON: Eventually we had to write our own assembler and all our own tools. That slowed us down considerably.

BRICKLIN: Later in the cycle, when we began to think about marketing the product, we talked with Dan Fylstra [BYTE's first new-products editor], who went to Harvard Business School at the same time I did. He had joined a firm called Personal Software, which at that time was the leading seller (and distributor) of personal computer software.

I wrote a prototype in BASIC, which I ran on Personal Software's Apple II. That Apple didn't have a mouse, but it did have paddles that you would turn to move the cursor from column to column. To change it to go from horizontal to vertical, you hit the fire button. Running in BASIC, it didn't respond very well, so I changed it to use the arrow keys to go back and forth, and the space bar to switch you from horizontal and vertical.

BYTE: Where did the concept of an electronic spreadsheet come from?

FRANKSTON: The spreadsheet concept had been around for hundreds of years. Companies used two to three rooms of blackboards or rolls of paper to do their production planning as rows and columns.

BRICKLIN: I came up with the idea of using fixed rows and columns for addressing. I realized you would want numbers in certain places—the columns-and-rows metaphor was for addressing purposes—and I needed some way to name them. Letters for columns, and numbers for rows seemed to be the perfect way to do it. We wanted at least 54 columns—a label, a total, a column for each week—and as many rows as you could get away with in memory.

BYTE: How did you decide on the name VisiCalc?

FRANKSTON: You'll notice that in our first ad in BYTE there's no mention of the word *spreadsheet*. When we were coming up with the product name, we specifically avoided the use of the name.

BYTE: Why? Were you afraid you'd scare people?

FRANKSTON: Yeah, we called it all sorts of things—electronic ledger, electronic blackboard, visible calculator—

that's what we finally based the name, VisiCalc, on.

BYTE: How long did it take to write, develop, and get VisiCalc ready for market?

BRICKLIN: Bob and I sat down with Fylstra, negotiated a contract (as authors and publisher), and started a company (Software Arts) to actually make this product. Bob wrote it; I took care of the specifications and the documentation. Before we shipped, I graduated from business school and went to work as chairman of the board of Software Arts.

The idea hatched in the spring of 1978; our commitment to produce a product with it came about in the summer; the prototype occurred in the fall (done in BASIC); the agreement to produce it was signed in the fall; the decision to do the company was made during the winter. We actually filed incorporation papers on January 2, 1979 (which is why January 2 is Day 1 of VisiCalc's date functions).

BYTE: Why did you write it in machine language?

FRANKSTON: Basically, I write in the highest-level language I can get away with. And on the Apple II, given the severe constraints of size and space and the lack of tools, there was no alternative in a 16K-byte cassette (32K bytes included the operating system, the disk-file system, the screen memory, everything). It was a space/time trade-off. We needed the speed; we needed the code to be small, and it had to bit-twiddle like crazy. The alternative was a much larger machine. I didn't write it in a low-level assembly language—we had macros.

BYTE: How did you decide what features to include and what to leave out? By the available memory?

FRANKSTON: We eliminated the need for almost all help or error messages. The program was meant to have context-sensitive interactive help and live graphics (we wanted the user to be able to split the screen and watch graphics at the same time), but there was no room. We did split the screen into two text windows and put in the titles. Our assumption was that you couldn't burden the user with anything. If something was complicated, we fixed it. For instance, in the Apple II, you could accidentally hit the Reset key, so we had to let you recover from that. In our design, ease of use and smoothness were more important than ease of learning.

BRICKLIN: We did have competition—our competition was people doing their computations on the back of an envelope. VisiCalc had to be as easy the first time you did something with a spreadsheet as it was the first time by hand. Then the second time was quick. It wasn't just a program we were making—we also had to create and typeset our own reference card and manual.

FRANKSTON: There was a reason why we did everything. We tried to reuse mechanisms. For example, we stored the spreadsheet on disk in keystroke format so we could use the keyboard reader to read it back in. We had to justify all the negatives.

BRICKLIN: That's right. For example, we didn't have commas because there was a bug, and it wasn't worth fixing it then because we had to ship. On the other hand, we had hoped to put in sine and cosine. But because of memory constraints, we decided we wouldn't include that feature. Unfortunately, we had mentioned it to Carl Helmers [BYTE's founder], and he had used that feature as an example in a product preview in BYTE. So we had to put them in. It cost us memory. Another thing we did, unheard-of then, was to use sound. We had two different sounds—one for error indication and another one for a limit—such as if you're moving the cursor and that's as far as the cursor is allowed to go, it would make a "thud, thud, thud."

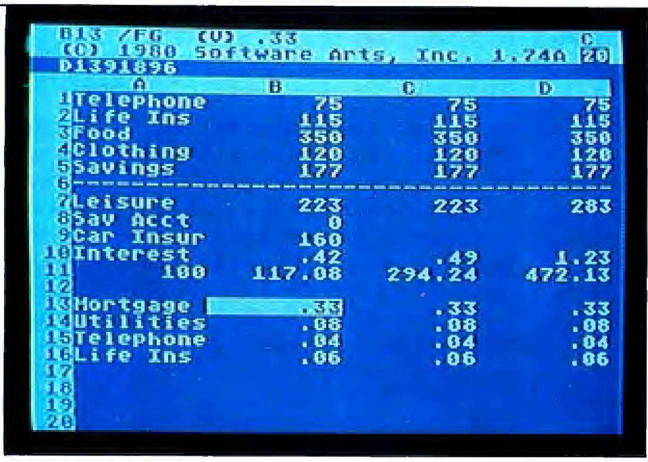

Photo B: *A screen shot from an early version of VisiCalc (1980) that ran on the Atari.*

FRANKSTON: Since walls aren't made of metal, a thud sounded right when you hit a wall, whereas a bell sounded right when you make a mistake.

BRICKLIN: When we were just about to ship, Apple told us it had this new language board that could give us 16K bytes more memory. We put in a quick fix to use 10K bytes out of the total. VisiCalc came out October 17, 1979, at $99, and people paid hundreds of dollars for the board just for the extra 10K bytes of memory.

BYTE: What was the public's reaction to this new "thing"? Did you have to educate them?

FRANKSTON: Nobody even knew what VisiCalc was.

BRICKLIN: It wasn't just the public; first we had to educate the dealers. Personal Software put out a demo script that the dealers stuck in their windows and let run all day. In those days, if you showed it to a programmer, he'd say, "Well, that's neat. Of course computers can do that—so what?" But if you showed it to a person who had to do financial work with real spreadsheets, he'd start shaking and say, "I spent all week doing that." Then he'd shove his charge cards in your face.

BYTE: Is it true that people really bought systems just to get VisiCalc?

BRICKLIN: That's what we've been told. A few dealers knew what they were doing and got their salespeople excited about it. Because of VisiCalc, one of the Burlington, Massachusetts, dealers became the most successful Apple

continued

dealer in the country at that time. Two of its salesmen ended up as two of the founders of Lotus (the original team that brought out 1-2-3). We only sold about 1000 a month for the first few months because we had to get the word out to the primary consumers, who were financial people. [Editor's note: *A total of over 800,000 copies were sold by May of 1985, when Lotus purchased Software Arts and ceased marketing VisiCalc.*]

It finally started selling, and we converted it to other machines—Radio Shack, the Atari, the Commodore, and, later, Sony and IBM. Early on, Hewlett-Packard licensed it and actually did the conversion itself. It took about a year to get them all converted. Tandy actually legitimized the name *spreadsheet*.

BYTE: Where did it go from there? And where, when, and why did the data interchange format DIF come in?

BRICKLIN: We realized we needed to move data in and out—open up this product. There were restrictions in Apple DigiBASIC. We wanted to make [VisiCalc] easy to read and write so nobody would have an excuse for not supporting it. So in February 1980, Bob invented DIF. It wasn't in the first version of VisiCalc. We wrote an article for BYTE explaining what DIF was. Eventually, there were four or five major versions of VisiCalc.

BYTE: But why you two? Why at that particular time? Why the spreadsheet?

FRANKSTON: Ask yourself why there are so many word processors and so few spreadsheets? The answer is because there were a lot more roots to word processing, and the spreadsheet put a heavier demand on the machine. The idea to implement financial forecasting by merging the spreadsheet with word processing in a commercial way hadn't been done. A lot of people had played with different parts of what later would become the spreadsheet, and there were a lot of things in the labs. IBM had done parts of it, and other people had financial forecasting systems, but the idea of putting it together on a machine that you could take home and fiddle with yourself hadn't been done.

BRICKLIN: When programmers who really knew what was happening saw Bob's code, they would tell us, "This is incredible." It really pushed the machine. Lotus 1-2-3 ran on a 256K-byte machine; VisiCalc ran on a 24K-byte machine, 32K bytes with disk. Each of them in its own world really pushed things and was very competitive.

BYTE: What do you see as today's problems, and what's coming that will change computing?

BRICKLIN: The things that turn me on are the new I/O devices—new physical configurations.

FRANKSTON: The big thing is the Nintendo [*laughter*]. The reason I'm saying that is—look at the idea of the DataGlove, virtual reality. A lot of this stuff is done only at the very high or very low end—either on a $100,000 machine or on a $100 machine.

BRICKLIN: The high-end machines were highly interactive. The midrange machines, such as the normal mainframes and minicomputers, weren't very interactive. VisiCalc was the low-end machine that ran on an Apple. The low-end machines like the personal computers are highly interactive. You can run Space Invaders on them.

FRANKSTON: Computers are part of the woodwork now. You expect them to be there, and that's a tremendous change. We're still in a pre-coalescent stage. You've got all of these devices—a copier, a fax. They have to play together well. And that's what hasn't happened yet. Fax is like CB. It'll go away by merging with electronic messaging. Fax became cellular phone. I can go both ways from E-mail to fax and back now, but in the long run, most faxes will originate in word processing directly from the computer, and they'll look so much better. But now your computer is your database and your word processing and your fax machine and your telephone answering machine....

BYTE: It'll have to become our central control.

BRICKLIN: I'm thinking of things like a 3- by 5-foot display. Multiple people can watch and interact at the same time. Some information is better shown in a bigger space. Why can't my entire desktop be a screen? Gestures and reflexes are going to be big things. Innovative I/O...sound. Here's a spreadsheet calculation that was all done on a Mac. [*At this point, Bricklin turned on a synthesizer, which "played" the sound of a spreadsheet calculating, the memory running down, and the final computations.*]

Why not sound and voice synthesis to give you positive feedback when you do something right? Why don't we have animation? You could do a spreadsheet and see what happens to profits: When they go down, you could see a ball rolling down a hill and then it goes splat.

FRANKSTON: But they have to have commercial promise. Right now, we're just learning how to share the machine. We're really going back to timesharing—hopefully, not in a stingy way. And, hopefully, we've learned our lessons.

bundled with LisaCalc. The short-lived Lisa and LisaCalc enticed spreadsheet users with its Xerox Star-like graphical user interface (GUI). It provided mouse support, multiple windows, cut and paste, and assorted fonts—personal computer features that were astonishing at that time. The Lisa failed to attract developers, and, by 1984, Apple abandoned it in favor of its Macintosh. Apple dropped LisaCalc and opted not to produce a spreadsheet for the Mac. While Context MBA and LisaCalc were important harbingers, neither succeeded.

In 1983, Lotus swept into the spreadsheet market with 1-2-3. Like Context MBA, 1-2-3 added graphing. However, a spreadsheet and graph could not share the screen. Furthermore, graphs were not automatically redrawn when the underlying spreadsheet changed.

Lotus 1-2-3 exploited natural-order recalculation, although it also supported VisiCalc's row- and column-order modes. Natural-order recalculation maintained a cell dependency list and recalculated a cell before recalculating cells that depended on it. To conserve memory, 1-2-3 resorted to a sparse matrix of

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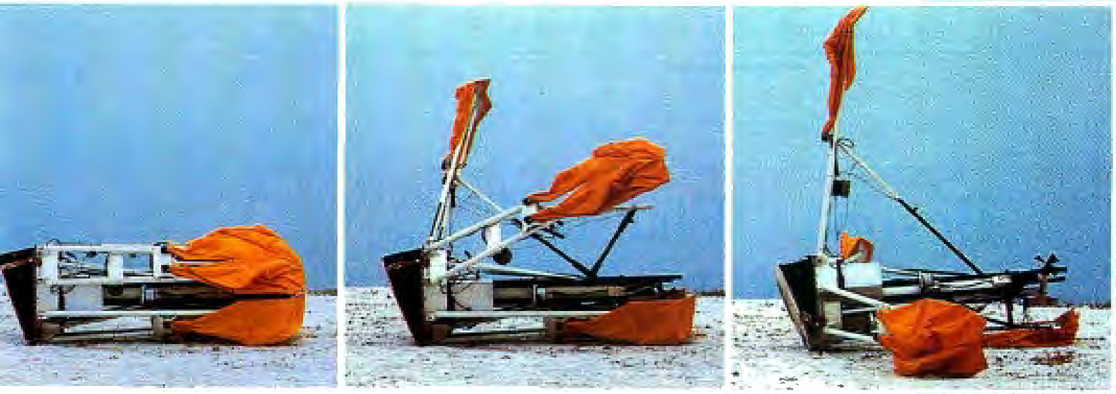

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Beyond "What-if?"

David P. Reed

When Dan Bricklin and Bob Frankston built the original VisiCalc, the spreadsheet metaphor was essentially an electronic worksheet that remembered what you did and allowed you to make small alterations to your calculations to see how they affected the results. But the basic spreadsheet metaphor grew rapidly to encompass a much broader range of functions. The parallel evolutions of spreadsheets and personal computer hardware were tightly coupled. Spreadsheets are perhaps unique among major kinds of software in that they push the limits of personal computer technology while letting the user take advantage of all its aspects.

The core of spreadsheet technology is instant response to user input as models and display presentations get more complex. The demand for more spreadsheet calculation cycles has grown faster than the boost in microprocessor speed. Over time, this demand has led to smarter recalculation techniques.

In the past three years, most spreadsheets have come to provide some form of minimal recalc to calculate only those formulas that might be affected by the change. Recent innovations include background recalc, which lets you move around, print, and so forth while the spreadsheet is calculating, and restartable recalc, which lets you enter new data before recalculation is finished. The next few years will bring techniques that get ever closer to "optimal recalc"—recalc before you perform it.

To provide ever-greater responsiveness, the newest spreadsheets are built around internal multitasking designs that allow instantaneous live display of data as you work, while prioritizing less important activities to background recalculation, print formatting, chart layout, and so forth. Beyond this improvement, we may see further exploitation of concurrency to anticipate what the users will ask next and to provide them with suggestions and other help.

As users tackled more complex problems, spreadsheets supplied more powerful analysis tools. Innovations included tools for repetitive evaluation, such as macros, and two-dimensional and three-dimensional table generation for case analysis. Other aids now include high-powered techniques such as regression and goal seeking. In the next generation, we'll see linear programming and mathematical optimization.

The framework of spreadsheet technology is the rows-and-columns metaphor, a powerful work organizer. As your other needs grow, so does your need to organize your work better. The desire for a better structure for large models has led to three-dimensional worksheets that allow the user flexibility to put different parts of a calculation on different pages of the worksheet.

Many users need to consolidate information from multiple worksheets. This led to support for multiple active files in memory. To link the worksheets, designers invented various features that transfer values among worksheets and worksheet files on disk. As file sharing on networks becomes possible, modular systems of worksheets, including live sharing of files on LANs among multiple users, becomes possible.

Ever-larger and more-complex worksheet structures bring about the need for better memory management. The LIM/EMS, DOS Extender technology, and OS/2's use of the 80286/80386 protected mode have fed the spreadsheet user's memory appetite. At the same time, spreadsheet programs use ever-more-sophisticated sparse-matrix data structures. In the newest spreadsheets, data compression techniques like Huff-

cell data pointers. With this scheme, it wasted almost no memory on empty cells and could represent bigger spreadsheets, up to 2048 rows by 256 columns. Lotus 1-2-3 added cell display formats, simple but useful commands that treated spreadsheet rows like records in a database, and the ability to name ranges of cells.

After 1-2-3, an all-in-one software fad subsumed spreadsheets. Ashton-Tate launched Framework, Lotus orchestrated Symphony, Apple published AppleWorks, and VisiCorp demonstrated VisiON. Lotus also fielded Jazz, an all-in-one for the Mac. Lotus folded Jazz after Microsoft practically monopolized Mac spreadsheets with its Excel. Excel delivered the GUI, windows, and multiple spreadsheets and graphs on the screen presaged by LisaCalc and Context MBA. It also offered user-extensible cell display formats and allowed array references in expressions. Microsoft later ported Excel to the IBM PC.

In 1983, the notebook-size Tandy TRS-80 Model 100 sported Multiplan in ROM. Later, Hewlett-Packard put 1-2-3 in ROM in a laptop. Low-cost shareware spreadsheets appeared. Most exceeded the functionality of the original VisiCalc. Spreadsheets even popped up as TSR programs and Mac desk accessories. Borland shipped source code for a feature-full spreadsheet as tutorial material with its Turbo languages.

Some companies even dissected Lotus 1-2-3 enough to weave their own programs into it. HAL, the first such program, added English-like commands and an undo command. What's Best! added goal seeking. The next releases of 1-2-3 and Symphony supported an official interface for such add-ins. Other spreadsheet makers followed suit, and a new spreadsheet add-in industry flourished. Yet, as spreadsheets grew richer, memory ran short. For IBM PCs, the 640K-byte barrier was so limiting that Lotus, Intel, and Microsoft coauthored a standard for accessing expanded memory, which most spreadsheets quickly adopted.

Doing 1-2-3 One Better

By 1985, a parade of Lotus 1-2-3-compatible programs had begun, each with idiosyncratic enhancements. Mosaic's TWIN provided better graphs. Paperback Software's VP-Planner directly read dBASE files and created *n*-dimensional spreadsheets. Javelin Software's Javelin understood time periods and allowed graphical input. Borland's Quattro had customizable menus and included a menu set that perfectly mimicked 1-2-3. Several companies released compilers that translated spreadsheets into either stand-alone programs or C code.

SuperCalc5 introduced three-dimensional spreadsheets, making previous spreadsheets into pages in a 255-page spreadsheet block. A SuperCalc5 spreadsheet could reference cells on other pages in memory or on disk. It could display any three such pages. SuperCalc5 accepted 1-2-3 files, commands, and macros, and the program even allowed mixing 1-2-3 commands with its own. Moreover, it added an undo command,

man codes and run-length codes pack more data into fewer bytes internally.

Over the last few years, spreadsheet presentation abilities have expanded dramatically. High-resolution color graphics on printers and personal computer display screens have driven the demand for more effective charting and printing. Live charts provide another way to do "what-if?" Colored cells, grid lines, fonts, and shading in the worksheet are now possible. They have led to a new application area—spreadsheet publishing—producing the best possible hard-copy output to present the results of spreadsheet work to others. As CPU power increases, spreadsheets could drive animated graphics for yet another alternative presentation mode.

Spreadsheets are beginning to provide direct access to external data. As personal computers are hooked up to shared databases, the row/column metaphor has evolved to provide a new kind of viewport on relational tables. Developers have invented database access standards that allow spreadsheets to deal with the diversity of types of external data sources.

In the future, the spreadsheet's ease of use may make it the primary tool for analyzing large amounts of shared data. Spreadsheet responsiveness also is a powerful capability that can allow the same type of user-programmable analysis of live data feeds as might come from scientific instruments and stock tickers.

Spreadsheets must remain intuitive. Recent innovations include new command modes, such as pull-down menus, setting sheets/dialog boxes, and direct manipulation of spreadsheet layout using a mouse. Natural language and speech input may also be coming. Perhaps more important directions are suggested by AI-based techniques, such as the "graph this" command, which guesses the best way to present a table as a chart. The next generation might see commands like "make this nicer."

The basic spreadsheet metaphor is the epitome of "programming by example." This concept has also been used in newer features, such as the database criterion range, the macro learn mode, and the newer, always-on, macro recording features. A key to ease of use are features that provide a "safety net." The first of these were warnings about destructive commands, such as large erases and automatic file backup. More recently, we have seen undo for single commands, undo for whole macros, and (in the next generation) multilevel undo features that will reduce the risk of user mistakes and misunderstandings.

A growing area of interest is the use of the spreadsheet as a programming tool to create specialized applications. Macro languages continue to be enhanced to support this area. Two new technologies, spreadsheet compilers and add-ins (and associated add-in toolkits), create the opportunity for developers to base substantial applications on the spreadsheet as a programming tool.

Finally, spreadsheets have begun to incorporate new kinds of debugging aids, such as single-step mode, dependency analysis, and spreadsheet auditing tools. Ultimately, you will use AI techniques to ask why something surprising happened in your spreadsheet.

There's still lots more to do. Personal computer technology will continue to improve, providing users with new domains to explore with ever-more-sophisticated spreadsheet tools.

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minimal recalculation (recalculating only cells dependent on changed cells), LAN support, direct reading of dBASE files, a macro learn mode, and macro libraries that were not tied to a particular spreadsheet.

Lotus's long-awaited 1-2-3 release 3.0 matched most SuperCalc5 features. It added background recalculation, which recalculates spreadsheet cell values while waiting for user input. It also could simultaneously display spreadsheet cells and a graph on the screen. Release 3.0 was the first spreadsheet that ran under OS/2, but it did not work under OS/2's Presentation Manager.

Macintosh spreadsheets remained friendlier and better at presentation-quality printed reports and graphs. Microsoft's Excel 2.2 allowed 256 fonts per spreadsheet. With it, the user could customize menus and help. Excel's help even listed 1-2-3 command equivalents. In addition, it exported warm-link spreadsheet data and charts to Microsoft Word, added color for the Mac II, and affixed notes to cells.

Ashton-Tate's Full Impact and Informix's WingZ staked out the presentation spreadsheet niche with enhancements aimed at presenting spreadsheet results. Both offered scripting languages. Their scripts were like Apple's HyperCard scripts and could be attached to spreadsheet cells and buttons. They went well beyond traditional spreadsheet macros in flexibility and performance.

Other platforms gained Lotus 1-2-3-compatible spreadsheets. Computer Associates put SuperCalc5 on IBM mainframes. The Santa Cruz Operation supplied SCO Professional, a multiuser spreadsheet for Unix. Access Technologies authored 20/20 for VAX systems. Still, Mac and PS/2 spreadsheets define the state of the art.

Down the Spreadsheet Road

Spreadsheets have grown from humble 32K-byte beginnings to fill 8-megabyte Macs and 16-megabyte PS/2s, yet their core has remained remarkably unchanged. IBM PC spreadsheets will soon drop their old-fashioned character-based interfaces and adopt graphical ones from Microsoft Windows and OS/2 Presentation Manager. Also, most spreadsheet vendors will develop IBM mainframe versions. Largely with Structured Query Language, spreadsheets will improve access to LAN- and mainframe-based database servers (see the text box "Beyond What-if?" above).

Other enhancements will include improved consolidation, goal seeking, compiled recalculation, and the ability to call spreadsheets from outside programs. In another decade, every user's toolbox will supply object-oriented spreadsheet components. For that story, check out BYTE's 1999 articles. ■

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THE INTEL 80860

Superscalar architectures bring a new level of performance to microprocessors

Neal Margulis

Editor's Note: *Earlier this year, Intel announced its first full-scale RISC processor, the 80860. The 80860 operates at up to 50 MHz and has been called a one-chip supercomputer. (See "Intel's Cray-on-a-Chip" in the May BYTE.) We asked Neal Margulis, Intel's chief applications engineer for high-performance processors, to provide us with this in-depth description of the chip.*

The 80860 microprocessor uses an advanced architecture to deliver balanced integer and floating-point performance. With over a million transistors, the 80860 contains a RISC core, an FPU, a memory management unit (MMU), a graphics unit, and separate instruction and data caches.

The RISC core and the MMU allow the 80860 to run multitasking operating systems. Its floating-point capability supports advanced modeling, signal and voice processing, and simulation and CAD applications. The processor provides the computation and display support for three-dimensional visualization. Visualization lets a system display an enormous amount of numeric data as computer-generated graphical images, from which users can easily identify patterns.

Unlike a typical system where these capabilities are spread across several chips, the 80860 was designed from the ground up to integrate all these features. The result is a fully defined architecture for handling integer math, memory management, high-performance floating-point math, and 3-D graphics.

The 80860 eliminates the need for support chips such as floating-point accelerators, vector processors, digital signal processor chips, and graphics coprocessors. A fully defined architecture that starts with the CPU eases the software developer's job and results in more powerful applications software.

Analyzing the Architecture

The major functional units of the 80860 microprocessor and the paths between them are shown in figure 1. By incorporating all the functional units on a single chip, the chip's designers were able to optimize the communication channels between them. The wide internal buses balance data bandwidth with the processing speed of multiple execution units. Separate 32-word register sets for the RISC core and the FPUs provide further support for concurrent execution.

The widespread use of pipelining throughout the chip enhances performance. The RISC core has a four-stage pipeline consisting of fetch, decode, execute, and write stages. The floating-point adder and multiplier also incorporate pipelining with three stages each. In addition, a three-stage load pipeline is matched to the external processor bus, which supports three outstanding cycles.

The RISC core fetches both integer and floating-point instructions from the instruction cache. The CPU allows the programmer to specify two execution modes: single- and dual-instruction.

Single-instruction mode is the traditional execution mode, in which instructions are fetched sequentially. Pipelining allows the sequential instructions to overlap so that multiple instructions are in various stages of completion at any one time.

The 80860 goes a step beyond instruction overlapping with dual-instruction mode. This mode initiates two instructions at once, one for the RISC core and one for the FPU. The FPU achieves one floating-point result per clock cycle and has "dual-operation" instructions, in which an add and a multiply operation execute simultaneously.

Programmers can combine the dual-instruction mode and the dual-operation mode to achieve three operations per clock cycle. With this execution model, the RISC core can execute load, store, and loop-control instructions during floating-point operations.

The result is that peak performance can be maintained while executing the inner loops of common applications. The on-chip data cache or external memory can load data into the floating-point registers.

continued

Graphics

The floating-point hardware of the 80860 processor efficiently performs graphics transformations, including the rotation, scaling, translation, and advanced lighting calculations required for 3-D graphics. Displaying 3-D images requires special operations for shading and for hidden surface removal. The graphics unit hardware speeds these back-end rendering operations (i.e., operations that go from polygons to pixels) using the floating-point registers and wide data paths to operate on multiple pixels simultaneously.

The graphics instructions include intensity interpolation, z interpolation, and z-buffer check. Intensity interpolation allows for smooth linear changes in pixel intensity or color. The z instructions let the programmer determine which objects should be displayed based on their proximity to the viewer. The RISC core also performs a pixel store instruction in parallel with the graphics operations.

Virtual Memory

The 80860 microprocessor supports an address space of 4 gigabytes. The MMU includes a four-way set-associative 64-entry translation look-aside buffer. The TLB translations are performed in one clock cycle and in parallel with the cache accesses.

The MMU implements paged virtual memory management and protection. The Intel 80386 and 80486 microprocessors have the same two-level paging scheme. This commonality allows these processors to interact more easily in a common operating environment, and it facilitates the porting of virtual memory software written in C.

RISC Instruction Set

In the 80860's instruction set, all instructions are 32 bits long and use the three-operand, load/store style typical of RISC processors (see table 1). The three-operand format allows arithmetic, logical, and shift instructions to specify two source registers and a destination register. The only operations that operate on memory are load and store, with arithmetic performed on the registers.

The core unit can execute instructions in one clock cycle. Several techniques allow instructions to execute in one cycle, although their completion may require additional cycles. Loads from memory take one execution cycle, and the next instruction

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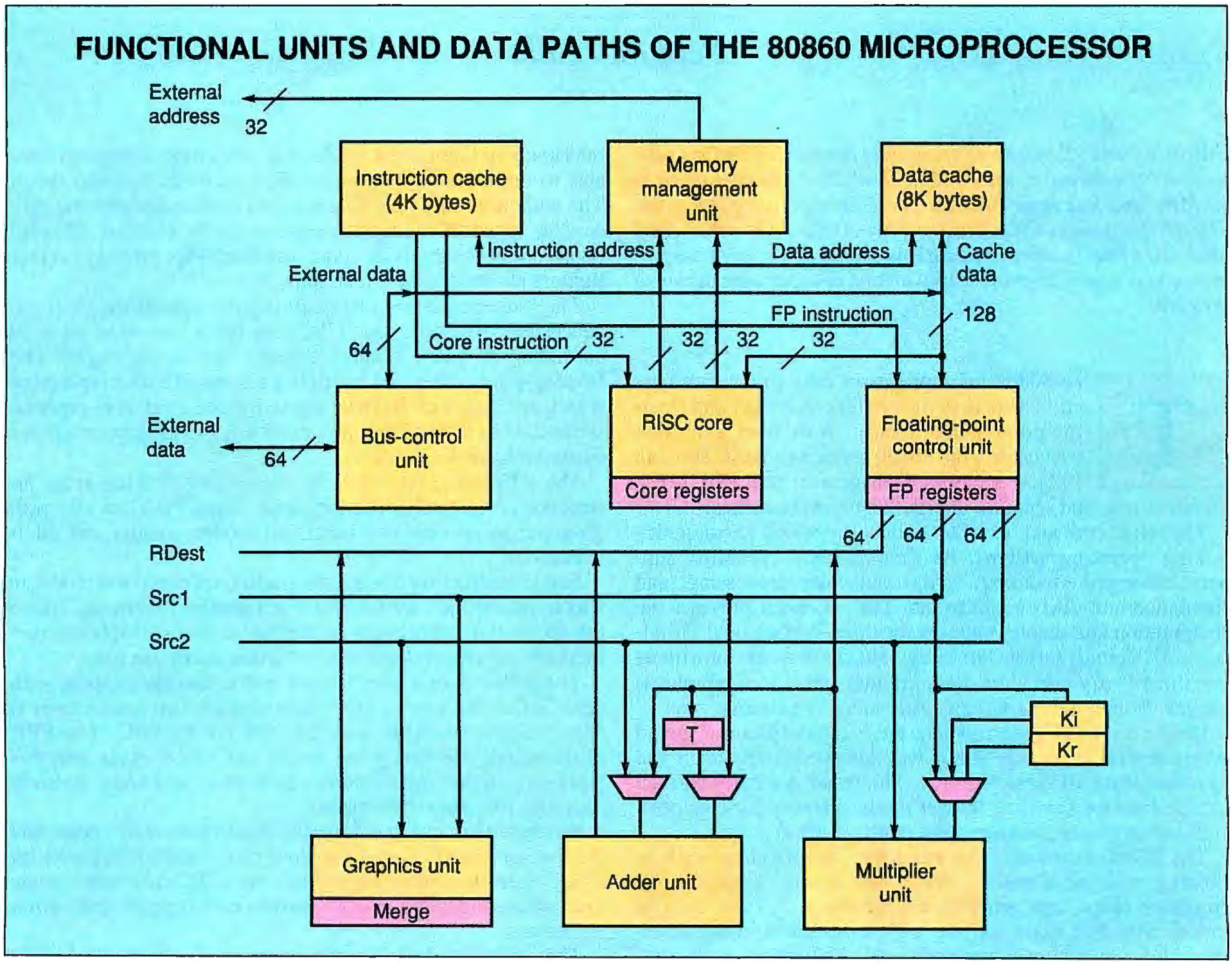

Figure 1: *Wide data buses inside the chip and an external 64-bit bus supply the necessary bandwidth to support multiple operations per clock cycle. Four floating-point registers can be loaded in one clock cycle with the 128-bit path from the data cache.*

Table 1: *The 80860 processor's instruction set has a full set of integer and floating-point instructions, each of which is 32 bits wide. The RISC core performs all the processor's loads and stores.*

THE 80860 MICROPROCESSOR'S INSTRUCTION SET

Core unit

Mnemonic	Description
Load and store instructions	
id.x	Load integer
st.x	Store integer
fld.y	FP load
pfld.z	Pipelined FP load
fst.y	FP store
pst.d	Pixel store
Register-to-register moves	
ixfr	Transfer integer to FP register
fxfr	Transfer FP to integer register
Integer arithmetic instructions	
ddu	Add unsigned
adds	Add signed
subu	Subtract unsigned
subs	Subtract signed
Shift instructions	
shl	Shift left
shr	Shift right
shra	Shift right arithmetic
shrd	Shift right double
Logical instructions	
and	Logical AND
andh	Logical AND high
andnot	Logical AND NOT
andnoth	Logical AND NOT high
or	Logical OR
orh	Logical OR high
xor	Logical exclusive OR
xorh	Logical exclusive OR high
Control-transfer instructions	
trap	Software trap
intovr	Software trap on integer overflow
br	Branch direct
bri	Branch indirect
bc	Branch on CC
bc.t	Branch on CC taken
bnc	Branch on not CC
bnc.t	Branch on not CC taken
bte	Branch if equal
btne	Branch if not equal
bla	Branch on LCC and add
call	Subroutine call
calli	Indirect subroutine call
System-control instructions	
flush	Cache flush
ld.c	Load from control register
st.c	Store to control register
lock	Begin interlocked sequence
unlock	End interlocked sequence

FPU

Mnemonic	Description
Floating-point multiplier instructions	
fmul.p	FP multiply
pfmul.p	Pipelined FP multiply
pfmul3.dd	Three-stage pipelined FP multiply
fmlow.p	FP multiply low
frcp.p	FP reciprocal
frsqr.p	FP reciprocal square root
Floating-point adder instructions	
fadd.p	FP add
pfadd.p	Pipelined FP add
fsub.p	FP subtract
pfsub.p	Pipelined FP subtract
pfgt.p	Pipelined FP greater than compare
pfeq.p	Pipelined FP equal compare
fix.p	FP-to-integer conversion
pfle.p	Pipelined FP less than or equal to
famou.p	FP adder move
pfamou.p	Pipelined FP adder move
pfix.p	Pipelined FP-to-integer conversion
ftrunc.p	FP-to-integer truncation
pftrunc.p	Pipelined FP-to-integer truncation
Dual-operation instructions	
fam.p	Pipelined FP add and multiply
pfsm.p	Pipelined FP subtract and multiply
pfmam	Pipelined FP multiply with add
pfmsm	Pipelined FP multiply with subtract
Long-integer instructions	
fisub.z	Long-integer subtract
pfisub.z	Pipelined long-integer subtract
fiadd.z	Long-integer add
pfiadd.z	Pipelined long-integer add
Graphics instructions	
fzchks	16-bit *z*-buffer check
pfzchks	Pipelined 16-bit *z*-buffer check
fzchkl	32-bit *z*-buffer check
pfzchkl	Pipelined 32-bit *z*-buffer check
faddp	Add with pixel merge
pfaddp	Pipelined add with pixel merge
faddz	Add with *z* merge
pfaddz	Pipelined add with *z* merge
form	OR with merge register
pform	Pipelined OR with merge register

Assembler pseudo-operations

Mnemonic	Description
mov	Integer register-register move
fmov.q	FP register-register move
pfmov.q	Pipelined FP register-register move
nop	Core no-operation
fnop	FP no-operation
pfle.p	Pipelined FP less than or equal to

can begin on the following cycle.

The processor uses a technique called *scoreboarding* to guarantee proper operation of the code at the highest possible performance. The scoreboard keeps a history of which registers have pending loads. The actual loading of the data takes one clock cycle if the data is in the cache, or several cycles if it's still in memory.

With traditional microprocessors, the next instruction cannot start executing until the data is returned. Scoreboarding allows execution to continue unless a subsequent instruction attempts to use the register being loaded. In this case, the processor will wait for the data to be returned. Optimizing compilers for the 80860 microprocessor organize the code so that such freeze conditions rarely occur.

The 80860's instruction set includes several control flow optimizations. Programmers can code conditional branch instructions with or without a delay slot. A delay slot allows the processor to execute the instruction after a branch while it is fetching the branch target. With both delayed and nondelayed variations, the compiler can easily optimize the code according to whether or not the branch is likely to be taken.

Branches can be performed conditionally based on the condition-code bit (e.g., `bc`, `bnc`, `bc.t`, and `bnc.t`) or through a comparison of two registers (`bte` and `btne`). There is also a branch-loop-and-add instruction, `bla`, that performs a test, a branch, and an add, all in a single instruction. This instruction reduces program loop overhead.

Floating-Point Instructions

The floating-point hardware can operate on either single- or double-precision IEEE standard 754 floating-point values and on 32- and 64-bit integers. The FPU includes pipelined add and multiply units, which can operate in either scalar or pipelined mode. Source operands for each unit are supplied by the general-purpose floating-point registers, by the special registers (e.g., KR, KI, and T), or by the output of the unit itself.

Scalar-mode instructions specify the operation, the source registers, and the destination register. Once issued, these instructions advance through the unit on each clock cycle until they are completed. Although only one scalar-mode floating-point operation can proceed at a time, it can be overlapped with the execution of RISC core instructions. Scalar-mode execution requires three clock cycles for adds and single-precision multiplies, and four cycles for double-precision multiplies.

Pipelined floating-point instructions advance the three-stage add and/or multiply unit by one stage with each new instruction. This explicit control allows a pipelined floating-point instruction to execute and produce a result with every cycle. Like the scalar-mode instructions, pipelined instructions specify the source registers and the destination register. However, the destination register of pipelined floating-point instructions is the result of a calculation that begins with a prior instruction.

In the example in figure 2, the adder begins by adding the numbers in f2 and f7. Because this is the first instruction of the series and the pipeline is not yet full, the result emerging from the adder is not needed and is sent to f0, which is always 0 and is used as a null destination. On each successive clock cycle, an add instruction is issued to advance the pipeline. When the sum of the first add becomes available at the result stage, it is stored to the destination specified by that instruction.

In this example, three cycles after the f2 plus f7 operation starts, the result is stored to f12 by the instruction that is initiating the addition of f5 and f10. Once all the desired add instructions have started, three dummy adds are used at the end to flush the desired results through the pipeline. When a long series of numbers is added, the overhead of filling and flushing the pipeline is negligible. When only one or two adds are performed, using scalar mode minimizes pipeline overhead.

Parallelism

Dual-operation instructions allow software to perform add and multiply instructions at the same time. One 32-bit instruction initiates both an add and a multiply operation. Although the two operations require six operands (four source operands and two destination operands), the instruction format specifies only three. The use of special registers KR, KI, and T, along with data-path bypassing, provides the additional operands.

The 32 variations of dual-operation instructions specify the source and destination operands for the adder and multiplier. With these instructions, programmers can efficiently implement applications such as fast Fourier transforms (FFTs), graphics transforms, and matrix operations.

The following example shows the acceleration that the use of pipelined operations makes possible. A series of 100 numbers is multiplied by a constant, added to a second series of 100 numbers, and stored:

```
DO 10, I=1, 100 10 X[i]= A[i] * C + B[i]
```

If the add and multiply are executed in scalar mode, a result is produced every six clock cycles. For example,

```
fmul C, A[i], temp fadd temp, B[i], X[i]
```

First the multiply is performed and the result stored in a temporary register. Then the add is performed with the temporary register, and the result is stored. Each multiply and add take three clock cycles, and the six-cycle sequence is repeated 100 times for a total of 600 cycles of floating-point execution time.

With pipelined, dual-operation instructions, the add and

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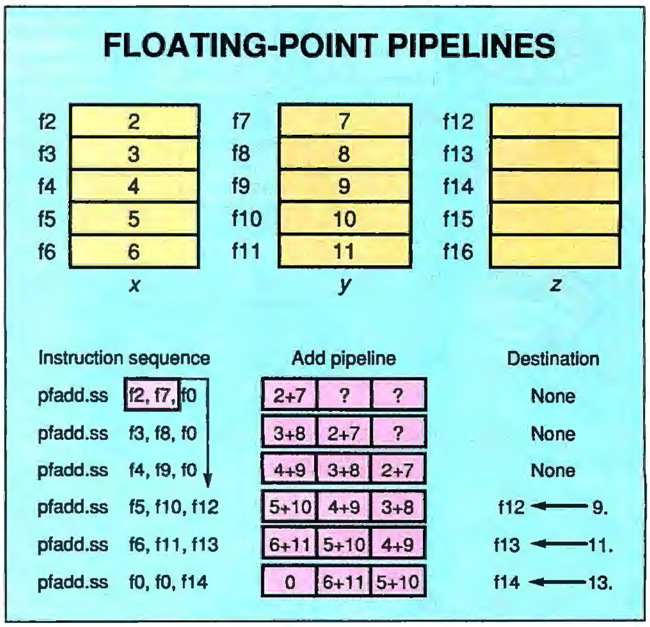

Figure 2: *The adder unit has a three-stage pipeline. Each instruction can start an add operation and store the result from a previous add. Every clock cycle produces a new result. Here the adder implements* z ← x + y.

multiply are performed in parallel and a new result is produced during each clock cycle. For example,

```
r2p1 B[i-3], A[i], X[i-6]
```

This illustrates the `pfam` dual-operation instruction variation specified as `r2p1 src1, src2, rdest`. The instruction specifies that the multiply is initiated with the constant register KR and `src2` as the operands, that the add is initiated with the result from the multiply and `src1` as the operands, and that the result from an earlier add is stored to `rdest`.

Because the three stages of the add and multiply pipelines are chained in series, the result comes from the operation that began six clock cycles previously. By overlapping the multiply and add, the loop of 600 cycles in scalar mode is reduced to 100 cycles of floating-point execution time.

The FPU's ability to produce new results every clock cycle gives it a tremendous appetite for data. To provide this data, the RISC core can operate in parallel with the FPU to move data in and out of the floating-point registers and to provide program flow control. The processor enters dual-instruction mode if you specify a `d.` prefix in the floating-point instruction mnemonic.

Once in dual-instruction mode, the instruction sequence consists of 64-bit aligned instruction pairs. The upper half contains the integer instruction, and the lower half contains the floating-point instruction. In dual-instruction mode, the 64-bit-wide instruction cache allows the execution of a pair of instructions every cycle. The modes can be changed with no overhead for any number of instructions.

By taking advantage of the 128-bit data-cache path, the RISC core can load up to four floating-point registers per cycle with the `fld` instruction. Also, a special load instruction called `pfld` loads the floating-point registers from external memory without the data being placed into the cache. This unique instruction allows data that will be referenced only once to be loaded from external memory, while data that is being continually referenced can be kept in the on-board cache.

Like the floating-point execution units, the `pfld` uses a three-stage load pipeline. This instruction specifies a load address and a destination register. Each `pfld` advances the load pipeline one stage and stores the result from the load address that began three instructions previously. Auto-increment addressing avoids using a separate add instruction by automatically incrementing the base register before each load.

Performance Evaluation

One common measure of integer performance is millions of instructions per second. At 40 MHz, the 80860 processor delivers 33 VAX MIPS (based on the Stanford integer benchmark suite) and performs 85,000 Dhrystones on version 1.1 and 80,000 on version 2.1. These results illustrate the RISC core's optimized instruction set and its ability to execute most instructions in one clock cycle. Combined with efficient memory management, the 80860 processor performs well in large applications that use virtual memory.

The Whetstone is a common benchmark used to gauge scalar floating-point performance. The 80860 processor achieves 24 million Whetstones at 40 MHz. The peak million-floating-point-operations-per-second ratings for the 80860 are 80 MFLOPS single-precision and 60 MFLOPS double-precision.

Although peak performance numbers are often misleading,

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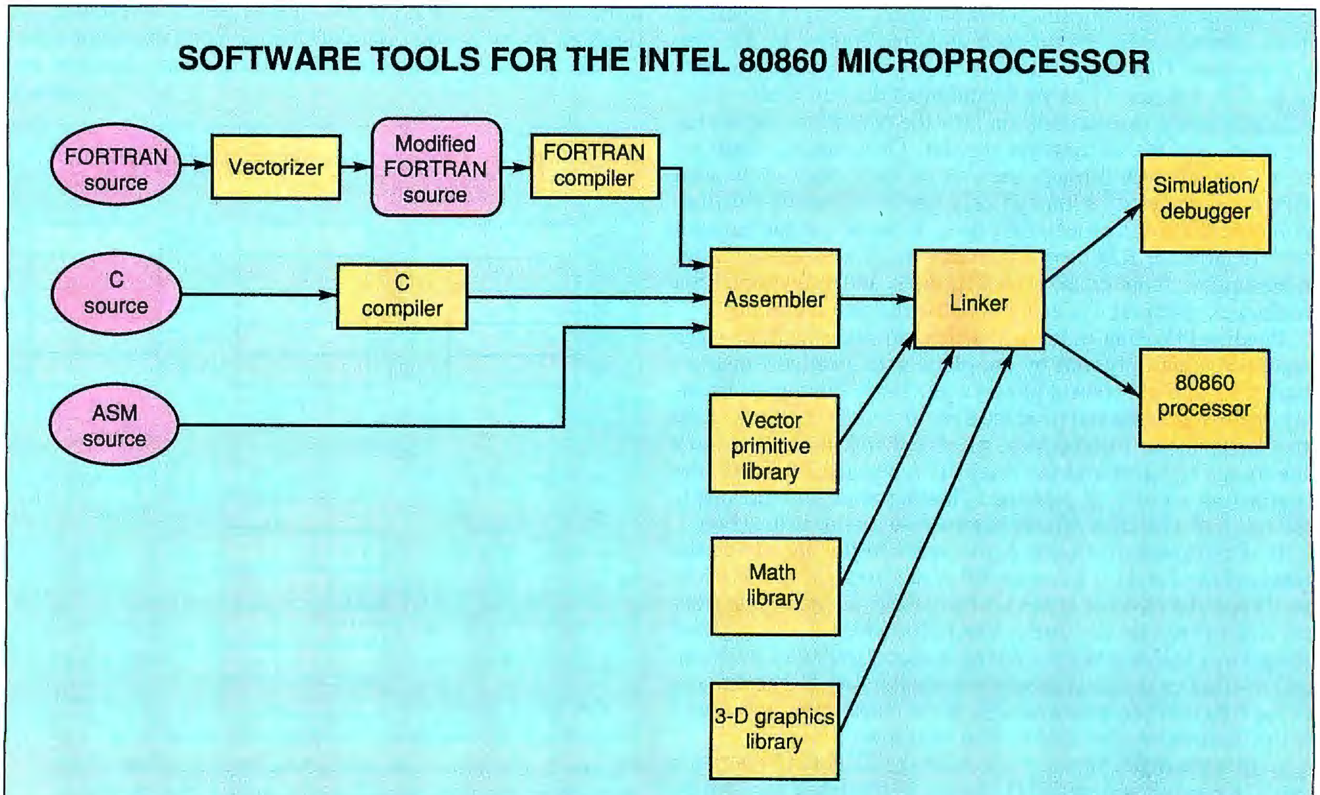

Figure 3: *Scientific FORTRAN applications take advantage of the vectorizing precompiler that automatically calls the vector library. C programs also can call the libraries.*

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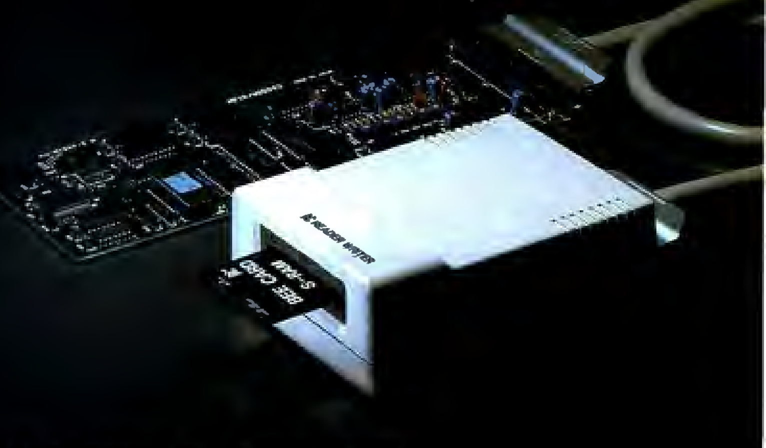

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dual-instruction mode and dual-operation mode allow the microprocessor to achieve peak performance for inner loops of common matrix operations. In the LINPACK benchmark, the 80860 attains over 10 MFLOPS. The inner loop of a complex FFT requires 10 floating-point operations. The 80860 performs the 10 operations in six clock cycles, calculating a 1024-point FFT in 1 millisecond.

Tools of the Trade

Intel's internal development teams and independent vendors are providing a full complement of software development tools and operating systems for the 80860. Figure 3 shows the development tools' environment, including C and FORTRAN compilers, an assembler/linker, a simulator/debugger, and a FORTRAN vectorizer. In addition, there are the mathematical, vector primitive, and 3-D graphics libraries.

The initial development environments use cross compilers hosted on Unix System V/386 and OS/2. The optimizations used in the compilers include coloring for register allocation, register-based parameter passing for calls, interblock common subexpression and loop invariant elimination, constant propagation, strength reduction, extensive peephole optimizations, and instruction scheduling.

Programmers write much of their engineering and scientific applications in FORTRAN because it is so well suited for vectorization. The 80860 support includes a FORTRAN vectorizing precompiler. Vectorization is performed on DO and IF loops, outer loops, and forward-branching conditional operations. The precompiler recognizes these structures and generates calls to a set of highly optimized, hand-coded procedures. These procedures take full advantage of dual-instruction and dual-operation modes, managing the data cache as a vector register.

In addition, programmers can access these procedures from other high-level languages. Work is under way to further increase the degree of parallelism of the processor. A library of assembly language routines for scalar mathematics is also available.

A multiprocessing version of Unix System V 4.0 is under development for the 80860. The project is a joint effort by AT&T, Unisys, Intel, Olivetti, Prime, Okidata, and others. The Intel programming tools will maintain high-level-language source code compatibility between the 80386, 80486, and 80860 microprocessors. A document is available that specifies an application's binary interface standard for the 80860 to allow portability of applications software across systems from different companies.

A Supercomputer on Your Desk?

The 80860 delivers balanced integer and floating-point performance that only a million-transistor processor can provide. Software developed for the 80860 can take full advantage of the architecture, bringing the power of supercomputers into the hands of desktop computer users.

But in addition to providing a new level of performance, the 80860 is the first of a new class of microprocessors. By breaking the one-operation-per-clock-cycle barrier, it has become the first commercial superscalar microprocessor. The advent of superscalar architectures will allow microprocessor performance to work alongside advances in semiconductor technology to bring even greater capabilities to desktop computers. ■

Neal Margulis is chief applications engineer for high-performance processors at Intel Corp. in Santa Clara, California. He can be reached on BIX c/o "editors."

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VGA/Mono	$1602	$1827	$1932	$2057	$2552	$3012
EGA	$1747	$1972	$2077	$2202	$2697	$3157
VGA/16Bit	$1837	$2062	$2167	$2292	$2787	$3247

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VGA/Mono	$2387	$2537	$2667	$2797	$3367	$3617
EGA	$2502	$2652	$2782	$2912	$3482	$3732
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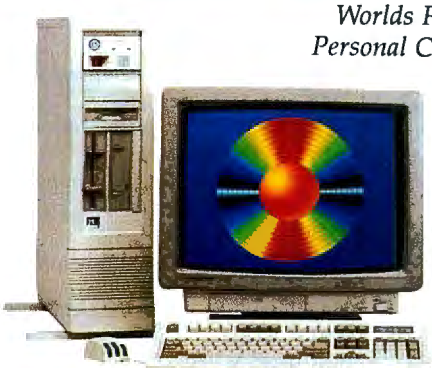

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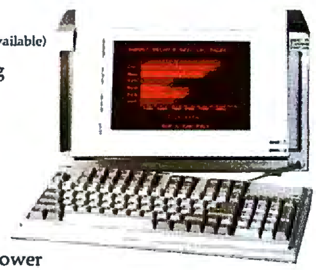

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CONFIGURING PARALLEL PROGRAMS

PART 1

The Occam Transpiler, now under development, will make writing software for parallel processing easier

Dick Pountain

Few people now dispute that parallel processing will ultimately be the way forward in designing faster computers. There is a limit to how fast you can make one CPU go, so to go faster means using more than one CPU. However, parallel processing is by no means a simple panacea.

For the first 40 years of computer history, programmers have been refining the art of writing sequential computer programs, and it's not always easy to see how such programs can be made to run on multiple processors; in other words, it's not easy to spot the inherent parallelism in problems. The philosophers' stone of parallel computing would be a completely automatic programming system that would let the programmer concentrate purely on the problem at hand and would hide all the details of how it is to be executed on a parallel machine.

Much of the current research into parallel-programming languages is directed toward helping the programmer to code problems in a parallel fashion without becoming bogged down in the details of how parallel processes (the concurrently executing parts of a parallel program) communicate with one another. New languages such as Occam, Linda, Parlog, and Strand offer widely different styles of parallel programming that assist the programmer in this way.

Spotting the parallelism inherent in a problem and coding it into a program is only a part of the solution. The parallel program then has to be fitted onto the group of parallel processors available for the job. This is known as *configuring* the program.

One way to tackle the configuration problem would be to build the ideally flexible parallel computer. It would have a huge (ideally infinite) number of processors, each connected to all the others by message channels of huge (ideally infinite) bandwidth. Topologists call this a "completely connected" network. Any program could be run on some part of such a beast.

However, even ruling out the infinities, such a computer is not practical. The total number of connections between the processors grows as the square of the number of processors, so for a machine with thousands of processors you would need millions of channels. The number of I/O ports on each processor grows linearly, but even a modest machine with 100 processors would need 100 I/O ports per chip; this is true of serial communication links, bus connections, and shared RAM ports.

For comparison, the INMOS transputer has just four serial links, while Thinking Machines' Connection Machine (possibly the most parallel machine made so far) has 64,000 processing nodes but only 12 links per processor, arranged as a 12-dimensional hypercube. The technology of VLSI sets limits to what is possible in this direction.

Another way to tackle, or rather to avoid, the configuration question is to go to the opposite extreme—namely, to fix the architecture of the parallel computer and completely integrate it with the software system. You design a parallel-programming language that assumes a particular layout of processors (e.g., a pipeline, a tree, a hypercube, or whatever) and then sell the compiler and its custom computer as a bundle.

Although this can work, it is unlikely to be acceptable as a general solution. No single parallel-computer architecture has emerged that is better than all the others, and there are convincing theoretical reasons to believe that no such architecture can exist. Each different topology is good for some classes of problems and bad for others—often so bad that it is worse than a conventional sequential computer solution. While you can certainly sell fixed-architecture solutions in specific problem areas, such as image processing or graphics rendering, such machines will not be general-purpose parallel computers.

So in the real world, you are likely to be faced with a finite network of processors and communications channels and with the ability to make only a few of the possible connections between pairs of processors. In these circumstances, you have to make decisions about how to map processes and messages onto processors and communication links. Often there will be more software processes than physical processors, and so you have to choose how many, and which, processes to run on each processor, and the same for messages and links. Choosing the best

continued

network of processors to execute a given program turns out to be an extension of writing the program itself. In this month's and next month's articles, I'll look at two different approaches to solving this problem, known to computer scientists as the *mapping problem.*

Choosing the best network of processors to execute a program turns out to be an extension of writing the program itself.

The Mapping Problem

Any parallel program can be thought of as being equivalent to a set of sequential programs executing at the same time and communicating with one another over abstract "channels," following Tony Hoare's famous Communicating Sequential Processes model (*Communications of the ACM*, 1978). The structure of a program considered in this abstract way is a network similar in kind, but not necessarily in detail, to the parallel-processor network on which it will be executed. The mapping problem then reduces to ensuring that neighboring processes communicating over a channel are mapped, as far as possible, onto neighboring processors that are directly connected—the goal being to minimize unnecessary communication.

Computer scientists describe these networks by means of *graphs*, which in this mathematical sense are diagrams composed of *nodes* (or *vertices*) connected by *edges* (or *arcs*). Both the parallel program and the processor network can be represented as graphs (see figure 1).

Graph theory is a well-developed branch of mathematics, and the mapping problem can be restated in terms of functions that operate on graphs: Find a function mapping one graph onto another that maximizes the number of edges in the first graph that coincide with edges in the second graph. If there are more vertices in the first graph than in the second, several vertices of the first graph will have to be mapped onto one vertex in the second graph; if there are fewer, then dummy vertices can be inserted in the first.

A formal mathematical treatment is beyond the scope of this article, but suffice it to say that stated in this form the problem becomes recognizable as equivalent to a well-known—and unsolved—problem in combinatorial math, the "graph isomorphism" problem. As with the related "Traveling Salesman" problem, all known algorithms for solving it have the disagreeable property of requiring amounts of computing time that rise exponentially with the number of vertices, so that even for quite modest networks, an exact solution becomes impractical. It seems as if the philosophers' stone has been snatched away before we have even started.

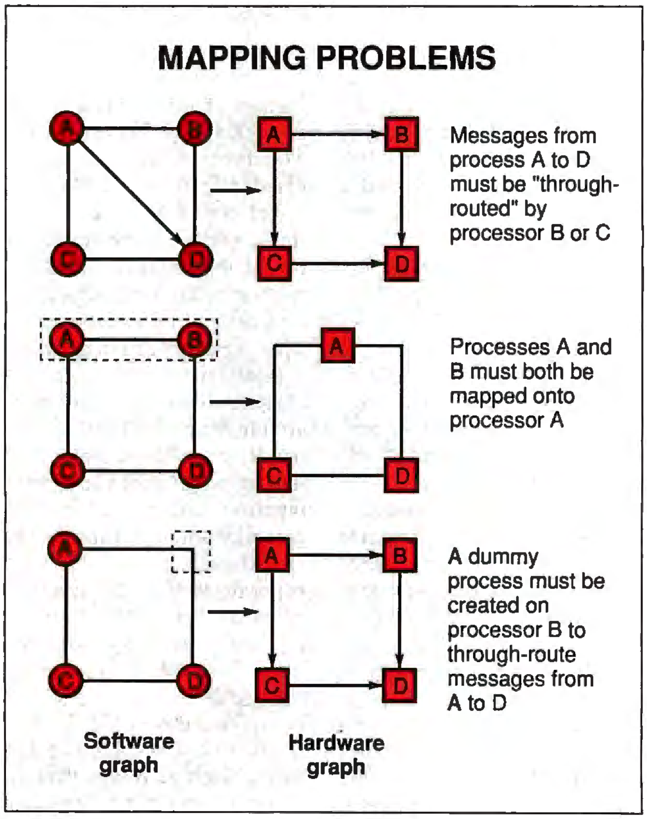

Figure 1: *A parallel program and the processor network performing it can be represented as graphs made up of nodes (or* vertices*) connected by edges (or* arcs*). The object is to maximize the number of edges in the software graph that coincide with edges in the hardware graph. If there are more vertices in the software graph, several vertices will have to mapped onto one (middle). If there are more vertices in the hardware graph, dummy vertices can be inserted in the software graph (bottom).*

Things are not quite so bad, however. Although exact algorithmic solutions are out of the question, there are approximate heuristic solutions that will give pretty good results in most cases. The system that is my subject this month uses such solutions to configure parallel programs written in Occam onto networks of INMOS transputers.

The Occam Transpiler

The Occam Transpiler is the result of a research project at the University of Berne in Switzerland by Daniel Meier and Andreas Wespi. I saw a prototype of the software working at this year's CeBit show in Hannover, Germany, on the stand of Concurrent Technology Systems (CTS), a firm set up by Meier and Wespi. The name *Transpiler* is meant to suggest a combination of transputer and compiler, in just the same way that *transputer* was coined from *transistor* and *computer* (i.e., a computer that is also a component).

The Transpiler is a software system that takes a source program written in Occam and attempts to configure it to run as efficiently as possible on a network of transputers. The Transpiler system consists of five major modules, themselves parallel programs that execute on the target transputer network (see figure 2).

The first two modules are analyzers that discover the structure of the parallel Occam program and the transputer network, or, in mathematical terms, that extract the software and hardware graphs. The graphs are produced as ASCII text files that can be inspected and edited.

These two output files are then fed to the third module, the mapper module, which attempts to solve the mapping problem for this particular case. The module does this in two stages, first placing processes onto processors and then placing software channels onto hardware links. It can insert dummy processes

and/or multiplex several channels onto a single link if the sizes of the networks do not match. The output from the mapper is then compiled by the fourth module.

In the prototype system I saw running at CeBit, the configurer output was a new Occam source program with all the correct PLACED PAR and link-to-channel assignments added to it. This was compiled with INMOS's TDS2 Occam compiler to produce an executable program; the Transpiler acted only as a preprocessor. Eventually, CTS hopes to produce its own transputer code generator so that the Transpiler will become a full compiler.

The fifth module is a performance analyzer that measures the loading of each processor in the network. Its output can be fed back to the mapper and then used to improve the solution of the mapping problem.

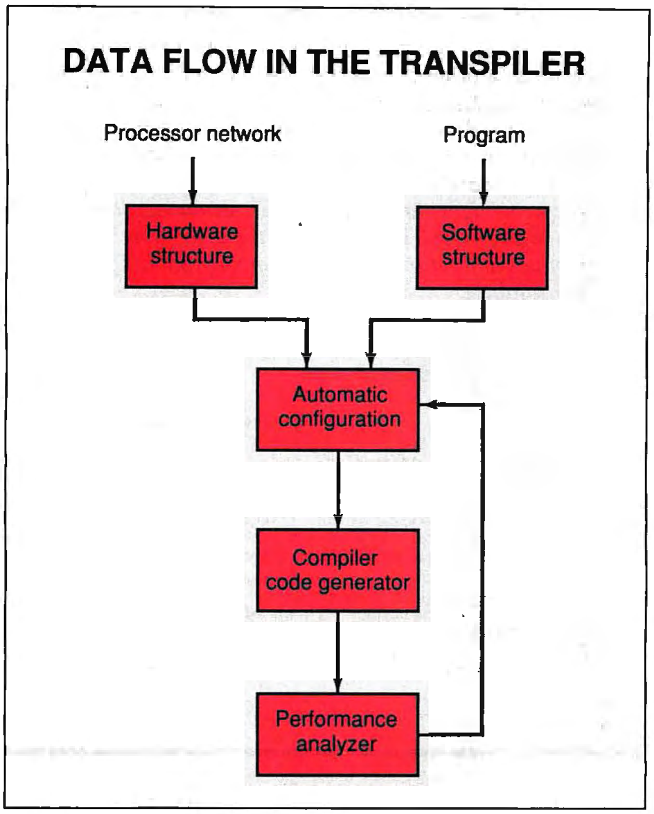

Figure 2: *The Transpiler system consists of five major modules, which are themselves parallel programs and execute on the target transputer network.*

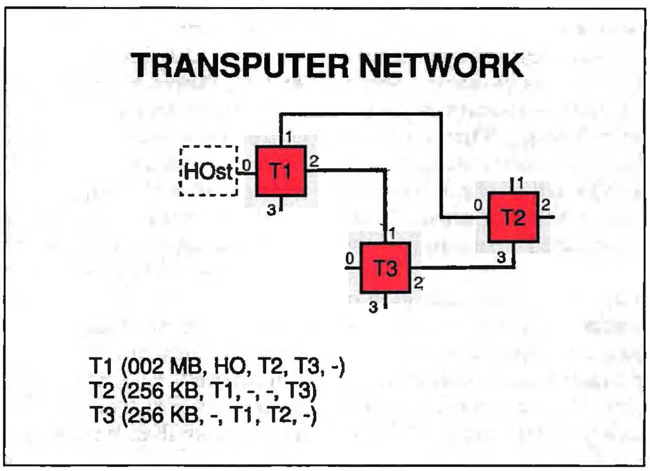

Figure 3: *A graphical display of a simple network, produced by a worm program. The program starts with the first transputer in the network (T1) and tests for the presence of additional transputers at all four of the transputer's links (0, 1, 2, and 3). It then transfers a copy of itself over the next link that has a transputer attached (link 1, to T2), and repeats the maneuver until the whole network has been covered. Finally, it produces the graph on the host workstation's screen (HO). The result of this hardware exploration is represented as "Transputer number(memory,link0,link1,link2,link3)," as shown for each of the transputers. A dash indicates that no transputer is attached at that link.*

Hardware Analyzer

The hardware analyzer is a worm program of the kind now routinely used to explore transputer networks. It works by loading a small program segment onto the first transputer in the network. This segment then inspects all four of the transputer's links by trying to boot the transputer at the other end of it. If it succeeds, it transfers a copy of itself to the next processor, which then repeats the maneuver until the whole network has been covered.

Things are not quite this simple, since it is possible that the network contains circular paths. Like a virus, the worm has to test a key memory location to make sure a copy of itself is not already present at a particular node.

The worm reports the link connections and the amount of memory that each transputer has. Figure 3 gives a simple network and the worm program's output based on that network.

The worm also produces a graphical display of the network it has discovered on the host workstation's screen.

Precompiler

The software analyzer is an Occam precompiler that inspects your program in two passes. The first pass collects static information for each procedure in the program: the channels that it uses, with their direction and protocol; the workspace required; and the expected computation time. This last figure is not easy to determine; in general, it is as difficult as the mapping problem itself. CTS uses a simple rule-of-thumb measurement: workspace size × code size. But this rule is subject to continuous improvement in successive versions.

True communication cost is difficult to determine, too, as it depends on the actual traffic on each channel at run time, and that is not currently measurable. Until it is, each channel has to be counted as a fixed communication overhead for the purposes of mapping.

The second pass identifies processes and their parameters (i.e., instances of calls to the procedures). From all this information a software graph is constructed, with a process at each node and single, undirected edges connecting the nodes; multiple channels between the same processes get reduced to one for the purposes of mapping. The information on channel direction and protocol is used only after the mapping stage, to generate legal Occam configuration statements.

Things are complicated by the fact that Occam allows processes to be built out of nested simpler processes, and it also supports precompiled units. For purely pragmatic reasons, the Transpiler treats a whole precompiled Occam unit as the smallest process that can be mapped, so it cannot split compiled code modules. This restriction allows the workspace requirement to be determined exactly.

continued

Mapper

The crux of the Transpiler idea is the mapper module, which actually does the work of adapting the software graph to the hardware graph. At Hannover, CTS showed three alternative mapping modules that are being evaluated, each of which uses a different strategy.

The simplest of these modules, called ADAPTER, uses a conventional graph-search algorithm. It generates a tree of all the possible mappings and measures for each the interprocessor communication cost and load balancing. The aim is to minimize communication cost and to distribute computing load as evenly as possible. As this is an exponential-time algorithm, the search tree may overflow memory for all but the smallest networks if allowed to grow freely. In ADAPTER, a tree-pruning strategy is used to reduce the chances of overflow, but it means that the best solution may be missed. ADAPTER can only be used for small networks.

Listing 1: *The pseudocode for an evolutionary mapping algorithm. A program could stop before the best possible solution has been reached because it got stuck in an evolutionary dead end. In this event, the algorithm simulates an environmental catastrophe by randomly swapping a number of processes and taking another pass through the algorithm. If this further evolution does not produce any overall improvement, the algorithm terminates and returns the best mapping that it's found as the result.*

```
Create first mapping by any method;
best := first mapping;
finished := FALSE;
WHILE NOT finished
  REPEAT                                {Evolutionary pass}
    improved := FALSE;
    FOR EACH process in mapping
      Try pairwise swap with all other processes and measure
          resulting fitness
      Select swap that gives best fitness
        If fitness gained >= 0 then make this swap permanent
        If fitness gained > 0 then improved := TRUE
    ENDFOR
  UNTIL NOT improved;
  IF fitness of new mapping < fitness of best
  THEN finished := TRUE;                {Terminate}
  ELSE best := new mapping
      Swap n random pairs of processes  {Apply 'catastrophe'}
  ENDIF
ENDWHILE
OUTPUT best
```

The other two modules, EVALCONFIG and MAPPER, both use variants of a probabilistic, evolutionary algorithm. Since they are conceptually similar, I'll just describe MAPPER, which is the focus of future developments.

Evolutionary algorithms are so called because they resemble the familiar Darwinian evolution of species by natural selection. Such an algorithm finds a valid but less than optimal solution to the problem using some naive strategy. Then it tries to improve this solution by making small random alterations to the parts ("mutations" in the analogy) and then checking to see whether the overall solution has become better or worse. Better solutions are kept and worse ones rejected ("survival of the fittest").

Algorithms like this have been applied to the simulation of thermodynamic systems, the annealing of metals, and neural network research. They can produce excellent, if not perfect, solutions in a short time. The fact that randomness is involved gives them the disconcerting property that they may arrive at a different (though close) solution each time they are run. For an evolutionary algorithm to work, it must be able to measure the fitness of each solution using a so-called "cost function." The Transpiler currently uses a cost function that incorporates both computational load balancing and (approximate) communication cost.

MAPPER is a parallel algorithm that runs on the target transputer network. A first solution is found by assigning processes randomly to processors and then letting each processor optimize its own local connections to its neighbors by applying the cost function. The overall mapping produced by this summing of local optimizations will not, in general, be very good.

The algorithm then moves toward a solution by swapping pairs of processes and measuring the effect of this swap on the fitness of the whole network; such an exchange may increase or decrease the quality of the overall mapping. Only those swaps that increase the overall fitness are made permanent. When every possible pair of processes has been trial-swapped, the whole business is repeated until no further increase in fitness is obtained; this constitutes one pass through the main body of the algorithm.

Unfortunately, this swapping strategy does not always converge smoothly on the best solution; the fitness may have stopped improving because the best possible solution has been reached, but it might also have become stuck in an evolutionary dead end. To escape such false endings, the algorithm ingeniously simulates an environmental catastrophe—the evolutionary equivalent of a kick in the pants. This is done by simply swapping a random number of processes to give a new mapping, which is quite likely to be a step backward, and then letting another pass of evolution work on it. The algorithm terminates if this further evolution does not produce any overall improvement (see listing 1). The best mapping found is then returned as the result.

The Future

Much work still remains to be done on the Transpiler. At this writing, Daniel Meier told me that CTS has decided to delay its commercial launch in favor of another year of research at the University of Berne. The latest version of the MAPPER algorithm can map a program of 100 Occam processes onto an arbitrary network of 32 transputers in about 3 seconds.

One unresolved problem is how to make the worm program detect peripheral devices connected to a transputer network. But the most difficult work concerns improving the cost function, which means more accurately measuring computational load and communication traffic. The favored method is to measure these directly from a simulation of the program's execution running on a single transputer.

Another possible route is to build up libraries of standard program building blocks (e.g., math functions) whose execution costs can be measured in advance. In a similar way, topology libraries for various commonly used hardware configurations (e.g., hypercubes or tori) can be constructed to simplify the mapping process.

Projects such as the Occam Transpiler should ultimately lead to programming tools similar to today's optimizing C and FORTRAN compilers, in which all the hard work of analyzing, mapping, and simulation is hidden inside a black box that the user just sees as the compiler. After that, the philosophers' stone of parallel programming might be within reach. ■

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THE WIZARDS OF THE MEDIA LAB

At MIT's Media Lab, researchers conjure up futuristic prototypes that could change the way we handle information

Janet J. Barron

In one room, red, yellow, and blue Legos busily build themselves into various shapes and structures, while a Lego robot makes tea. In another room, music emanates from a lump of clay. In yet another room, a minuscule area on a giant-size monitor contains gigabytes of information.

Such scenes—the stuff of science fiction movies—are everyday occurrences at the MIT Media Laboratory, a high-tech think tank dedicated to exploring new ways for humans to interact with every imaginable type of media.

In existence for five years now, the Media Lab was created by a nucleus of people under the direction of interface pioneers Jerome Weisner and Nicolas Negroponte, who saw the need for intensive research directed toward the interface between human beings and technology. Roughly 100 corporate and nonprofit agencies fund the Media Lab's research program, the primary goal of which is to generate innovative prototypes. These funds, grants, and endowments enable the lab to recruit top-notch researchers and give them the resources to tackle a variety of futuristic experimental projects.

Computers are a basic ingredient of this rarefied research atmosphere. If you could wander the halls of the Media Lab, you would see HP Bobcats (Motorola 68000-based workstations that do most of the Lab's heavy-duty processing), Sun and Lisp machines, minicomputers, five mainframes, and a Connection Machine. By far the most prevalent machine these researchers use is the personal computer. In fact, the Media Lab averages over two of these per person.

As a working, dynamic research facility, the Media Lab's structure is in constant evolution. The lab is loosely organized into 12 functional groups, or *domains*. The domains most interesting to personal computer users include spatial imaging, advanced TV research, the visible language workshop, music and cognition, vision science, film and video, movies of the future, speech research, and the school of the future. Each domain is presided over by one or more nationally or internationally renowned figures.

Photo 1: *This digitally modeled "Still Life" illustrates the use of reflection-mapping and texture-mapping techniques to produce striking three-dimensional images. (Photography: Plesniak/Klug, Spatial Imaging Group. All photos courtesy of the MIT Media Laboratory.)*

Images and Imagination

The Media Lab's spatial imaging group works under the auspices of Stephen A. Benton, inventor of the rainbow hologram. Holograms can be produced in a variety of ways. The most familiar of these are laser-transmission holography, reflection holography, and rainbow or white-light-transmission rainbow holography. Rainbow holograms lend themselves easily to inexpensive mass production by surface relief embossing. Photo 1 shows a computer-produced hologram.

Most of the innovative holographic applications currently under exploration rely on holographic optics' unique

continued

ability to combine and simultaneously process information that is distributed across a plane or scattered throughout a volume. Consequently, according to Benton, holography will someday be used in applications in scanning technology; fiber-optic multiplexers and demultiplexers; data encryption, storage, and processing in optical computing; pattern recognition; nondestructive testing; holographic movies and video; and three-dimensional laser photography. Some of these uses already exist in rudimentary forms, and all are being researched.

Some problems need to be overcome before we can adopt a medium with images in a fully three-dimensional form. These include developing a process to record true color, the ability to produce larger (1-meter-square) holograms, the advent of a commercial holographic laser printer, and the projection of large-scale moving three-dimensional images.

With the help of computers and video equipment with resolutions approaching 2000 by 2000 pixels, and increases in machine capacities and speed, Benton and his research group are gradually finding ways around these fundamental barriers. One result of Benton's work is the possibility of using personal computers to create holograms. Such a process, heretofore unthinkable, is now feasible thanks to current three-dimensional CAD software and powerful personal computers such as the Mac II. Essentially, there would be two phases of creating a hologram on a personal computer. Given the right kind of rendering software, you would build up a scene by creating objects and adding shading and reflections; you would then make 100 pictures of the scene as seen from side-by-side viewpoints and write all the information to a floppy disk.

In the second phase, you would send the data to a lab, which would optically combine your images on high-resolution film to produce the final hologram. At the moment, one of the logistical problems with this scenario is that, as yet, there are no commercial labs that will do this part of the process.

Photo 2: *With hardware rendering of three-dimensional shapes now practical, Media Lab researchers are conducting experiments with 3-D representation of programs. In this 3-D graphical debugger, the boxes represent program elements; they change size, position, and color as the program runs. (Photography: Lieberman, Visible Language Workshop)*

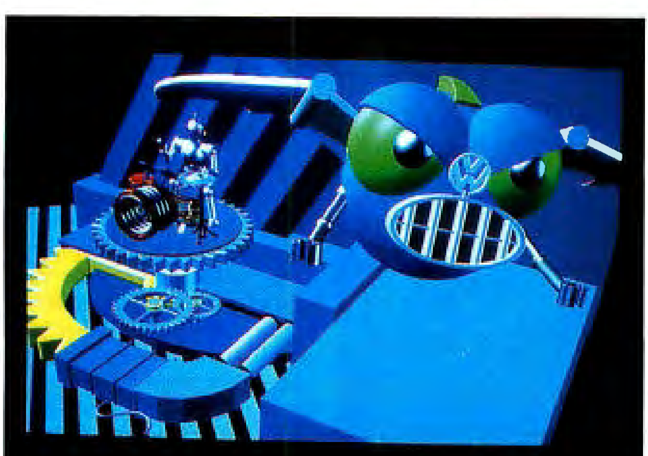


Photo 3: *A scene from "Beat Dedication," award-winning animation created with a system that combines a key-frame animation system with a solids-modeling package. (Photography: Sabiston/Small, Visible Language Workshop)*

Talking with Pictures

The Visible Language Workshop, led by Muriel Cooper, researches the uses of graphics in all forms of communications, notably the area of electronic communication. In their research, members of the workshop use film, illustration, typography, images, and sound. Several challenges face the workshop's programmers and graphics designers as they explore design tasks that are amenable to machine modeling, including the need for real-time visualization techniques, rapid prototyping, and organizing materials. Photo 2 shows an example of their work, a three-dimensional graphical debugger, while photo 3 shows a scene from the award-winning animation "Beat Dedication," produced by the Workshop.

Patrick Purcell's work in this area is directed at the way knowledge-based design systems can enhance the design process, whether it involves graphics, architecture, living environments, and so on. Purcell is also involved in the development of electronic image libraries and the technology of image delivery systems. This technology is being created to make image collections easily available to the general personal computer user and those who want to integrate these graphics into electronic publishing environments. The project currently consists of approximately 200,000 images, but it will ultimately embrace the full MIT Rotch Visual Collection of well over 400,000 color and black-and-white images. Using a LAN to query the database and (currently) campus TV cable channels as a delivery system, users will be able to access these images on the same scale and with the same ease of access that people retrieve text today.

Moving Pictures

The Computer Graphics and Animation domain researches issues of dynamic movement of objects in a context of goal-directed animation. Among its current projects is Bolio, software that acts as an environment for developing models for computer

animation sequences. Bolio (derived from the name of an ice cream shop favored by the Lab's researchers) provides researchers with a large library of graphics routines and some standard interfaces for communicating with other embedded applications.

Among the animation and simulation techniques currently in use is an inverse kinematics system that handles the physics of animation (e.g., making balls bounce) as well as the way animated figures move. Here and elsewhere in the Media Lab, researchers use devices known as the DataGlove and DataSuit to plot human activity (see "Between Man and Machine," September 1988 BYTE).

Computer graphics have long been used in architecture, but the results of research by another leader of the group, David Zeltzer, could enhance this productivity tool. To check out specific systems, such as the heat load in various rooms, for instance, Zeltzer's system would allow architects or engineers to use simulated people walking around in a simulated building. Another application of graphical modeling would be simulating dynamic action, such as the movement of a skin transplant on a burn victim.

Future Television

Berndt Girod, a new member of the Media Lab, says, "We are proposing something for TV similar to what happened with personal computers. It's a standard backplane that different manufacturers can make various modules to plug into. Then, when a new standard comes along, you'll be able to plug another card into the backplane." Girod thinks that the adoption of such a "superstandard" will allow manufacturers to integrate the TV and the personal computer. He notes that there are already workstations that have pop-up windows with TV programs running in them.

According to Girod, we may soon be able to transmit digital movies and video with acceptable quality at 64,000 bps (through an enabling technology such as ISDN). We may even be able to integrate visual (face-to-face) communications in a new type of E-mail called *video mail* that will allow you to send and receive video messages on your computer screen. "ISDN is basically here, and one of the nice things we can do with it is transmit pictures," says Girod.

Work is under way on video telephony, the real-time transmission of a sender's image (as opposed to sending prerecorded images), says Girod. This will require improved compression techniques. "A simulation of videophone transmission compressed to 64,000 bps can display only 10 pictures a second, while film displays 24, and TV displays 30 pictures a second."

And for those who dread the thought of people on the receiving end of your computer being able to see you, say, early in the morning, Girod has an answer. He posits that in-progress work on three-dimensional modeling will result in the ability to build a three-dimensional model of a face of your choosing. Then you'll be able to transmit the image of a still face that you like and also animate that face to respond appropriately to the conversation on the transmitting end.

One of this group's long-term goals is to make real three-dimensional holographic TV possible (not just stereo with glasses, says Girod). Workstations will be the first places we'll see this kind of display, but again, problems in signal processing and data compression remain to be solved before the technology will be available.

Speech Research

Chris Schmandt, of the Lab's Speech Research domain, has at least one major research goal, and that is to figure out how humans and computers can interact by voice, to "get a machine to do what a secretary can do." As Schmandt says, "A personal computer is my node"—his connection to the outside world. Part of this domain's research involves dealing with voice intonation, speaker intent, and natural language input.

Says Schmandt, "The concept that the voice will replace the keyboard is fallacious. The keyboard is a very effective input device. But using the voice to create documents is very difficult, and it's almost impossible to recognize unconstrained speech. In 10 years, if you can sit down and talk to your computer, you'll be lucky."

Currently, the speech research lab is building a program called the Backseat Driver that will run in your car and help you plan your route. Plans are to enhance the program with the addition of timely traffic information.

Film and Video

The Media Lab's film and video department is committed to technological advances in both the content and the medium itself. The department has been involved in bringing the advantages of random access to film via the use of the videodisk—that is, letting users access specific film scenes and information, just as they access data on their hard disks. Photo 4 shows a screen shot of the video storyboard system.

Historically, with a documentary, one person selectively decides what the viewers will see. Researcher Glorianna Davenport is developing an interactive magazine-type format that uses movies, text, graphics, photographs, sound, and video in a system that would allow viewers to orchestrate their own dynamic presentation of the information.

Davenport and Andy Lippmann, of the Lab's Movies of the Future domain, are researching ways to allow viewers to experience information from their particular point of view. Currently, different perspectives of a subject are being filmed and then digitized using an MIT-created video workstation—a hybrid with an IBM 5081 head, a DEC processor, and a parallax frame grabber digitizing at 30 frames per second.

continued

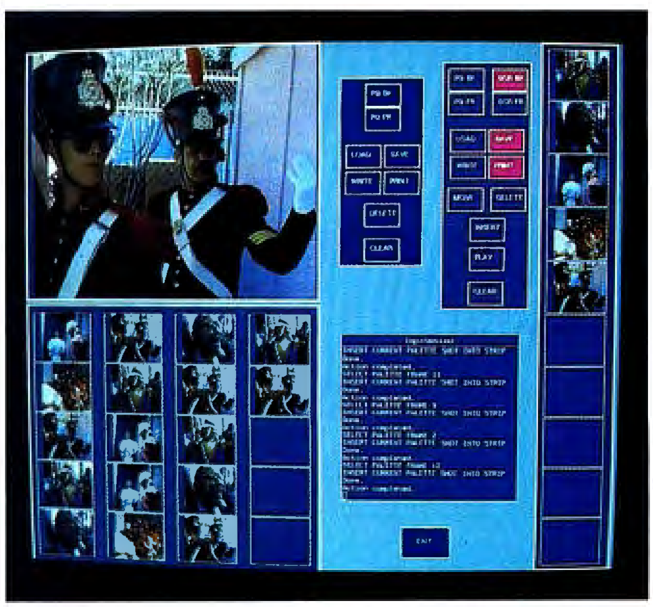


Photo 4: *This video storyboarder runs real-time digital video on a Unix-based workstation running X Window. (Photography: Pepe/Sheldon, Film/Video Group)*

In the near future, Davenport expects the technology to migrate to where it can be further developed and refined in a Mac environment. "Eventually, we want to be able to use personal computers to view, annotate, reconfigure, and distribute personalized information and entertainment material," she says.

Using specific distance information provided by a range camera and other esoteric equipment, a student of Lippmann's is working on a project to build a three-dimensional database of the objects in a scene. But until we understand how our eyes see, Lippmann says, he probably won't be able to perfect it. "If he does a good job, he graduates," the professor said, laughing.

Electronic Publishing

The Media Lab's Electronic Publishing domain covers a number of research areas that ultimately could change the way we transmit and receive electronic information. One of those areas is *narrowcasting*, the opposite of broadcasting. Narrowcasting could be defined as the production of dedicated electronic information and the communication of that data to only users who have specified it as their particular interest. For instance, the system could direct information having to do with marine biology to a scientist at Woods Hole SeaLab who has requested that subject as his specific interest.

Walter Bender, head of this project, notes that we currently use spreadsheets on personal computers so we can learn, analyze, and manipulate very primitive data types, such as alphanumerics. But we are inventing new data types, such as images, movies, and sound. To use current communications metaphors, we want to change the broadcasting of sound and images from analog-facsimile equivalent to digital-ASCII equivalent: With ASCII, you can manipulate information and perform syntactic and semantic analyses denied to you in the analog medium. Photo 5 shows a real image whose three-dimensional aspects have been captured so that the apparent light source of the scene can be changed.

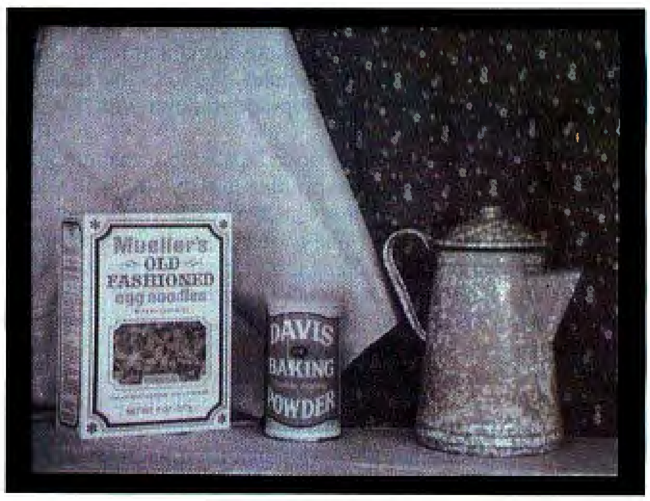
Bender's group is working toward the day when your machine will be on an intellectual par with you and be able to relate to you as an equal. "Right now, it's just an appliance that you manipulate," Bender says. "But one day you'll use your personal computer as an agent, to play devil's advocate—argue with you for or against an issue. Instead of signal processing, we're really after semantic processing, where a machine will be doing stuff with you, instead of your doing stuff to it."

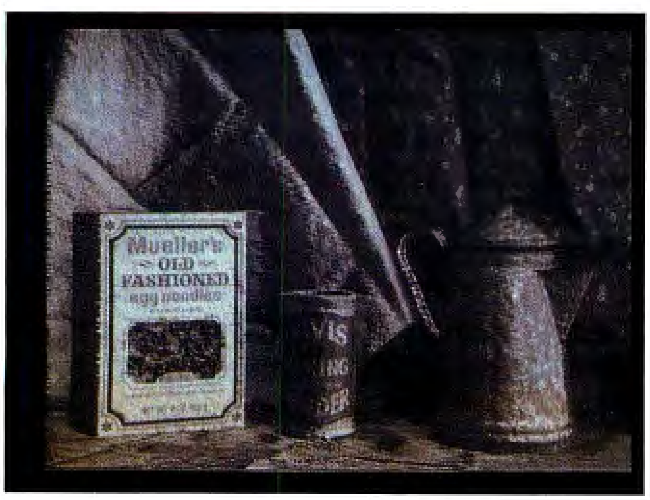
Bender also spends some of his multitasking time "people watching" and believes that computers should be able to do this, too. "Computers need to have a 'presence detector' to know whether or not you are there (at the computer) and paying attention," he says. "That knowledge is important. If you aren't, the computer won't flash important information at you, and it can go off and do maintenance until you turn your attention back to the machine."

Even more interesting would be the computer's ability to understand your facial expressions. "Ultimately," Bender

continued

Photo 5: *This series shows computer-graphics manipulation of a real scene. Camera-sensing range information lets the artist change the real image in the photo at right to either of the photos below, in which the position of the light has been synthetically altered. (Photography: M. V. Bove)*





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PC DIGEST ... gave five stars to our 1200 bps modem and top-rated our 2400 bps modem.

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The Vision Science domain is also researching new techniques of image data compression.

adds, "each computer will have built-in smile and frown detectors. But it's not clear yet what a smile is. Certainly, it's more than just a visual image—a smile is an emotional feeling, too." Conversely, Bender envisions a portion of your computer screen with a face that would frown at you if it doesn't understand what you want it to do.

Visions of the Future

In the Vision Science domain, one of the projects most likely to see results in the not-too-distant future is involved with computer vision. Computer vision—the adaptation of machine vision systems to personal computers—could have a tremendous impact on how we use our computers. However, this is a difficult area of research, according to Edward Adelson, who cochairs this domain along with Sandy Pentland.

"We're coming up with chips appropriate for vision systems, and we already can do simple operations in parallel and do them fast," says Adelson. "Conceptually, and in the hardware world and signal and parallel processing world, we are making lots of progress. But we still have a long way to go."

The Vision Science domain is also researching new techniques of image data compression, such as methods to store gray-scale and color images in as little space as possible.

The Man-Machine Interface

The Human Interface domain is currently researching the interface between people and communications, and the actions that take place at that interface. Richard A. Bolt and his crew are focusing on speech, gesture, and eye contact and the combinations thereof.

According to Bolt, it would be more effective and easier if, instead of having to interface with our machines via a keyboard, mouse, or DataSuit, we could use what he calls *subcarriers of communication*. These are actions such as shrugging, smiles, body language, winks, eye contact, gestures, and speech. "Interfaces such as eye tracking won't eliminate the keyboard and mouse," says Bolt. "They'll provide additional ways for you to interact with your computer."

One of Bolt's graduate students is developing a prototype called a *self-disclosing system*. The system, composed of a planet with volcanoes and staircases leading nowhere, is a three-dimensional world in a microcomputer. A host talks in synthesized speech about subjects that you tell it you are interested in, that it infers you are looking at, or that you point to on-screen.

"Most of us can't program in C or Lisp or use Unix, but we all use speech, gestures, and eye tracking," Bolt notes. "In five or 10 years, truly new flavors of dialogue and exchange may be possible."

The Sound of New Music

The combination Music and Cognition domain is directed by Marvin Minsky, Tod Machover, and Barry L. Vercoe. The

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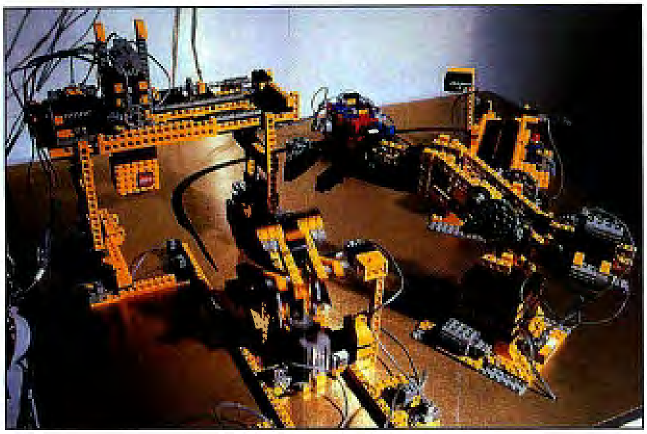


Photo 6: *A model of a factory assembly line, constructed from "intelligent" Lego elements controlled by an Apple-based Logo program.*

internationally known Minsky (author of *The Society of the Mind*) plays a dual role in the Lab's activities. He not only pursues his own specific research in AI, he also pays attention to the field of music as an "epistemological opportunity to understand fundamental properties of the human cognitive system."

Minsky's goal is to make a machine that has common sense. "Someday you'll plug into your computer a big ROM that will know most things that most people know. For instance, it'll know that people get mad if you take their things away from them, or, if you paint something, it stays that color for a while.

"Some work has been done on common sense, but right now, computers can only do things that we can buy applications for. It's much harder for them to provide personal services than commercial services such as standardized widget work."

Tod Machover's goal is to analyze how our minds work when they create or process music and then to see how we can and do use these principles. He carries out this global undertaking in a number of ways.

"The personal computer is the brain of the whole concept," he says. "This kind of thing can't be done on mainframes because they aren't fast enough. For this kind of research, you need immediate feedback." When there aren't traditional ways of doing things, Machover invents new ones, often including new instruments. For a project that he undertook before coming to the Lab, he invented a new type of orchestra consisting entirely of personal computers. Actually, the musicians were people playing a new genre of instrument coupled to the computers.

Among Machover's inventions are *hyperinstruments*, which combine machine-augmented instrumental techniques, knowledge-based performance monitoring, and intelligent music-structure generation. He uses hyperinstruments to research what human performers do well, to study their reactions, to abstract and separate them from the sound, and to get them away from pressing one key with one result.

Machover uses a Mac II for much of his work. He has written one music system in which he coded the knowledge base in Common Lisp and now is working on formalizing the knowledge to continue to build the system. His goal is to have the computer, given a score and performer tolerances, be able to compose its own accompaniment, orchestrate it, and do the sound and color.

Machover's group is also studying what kind of gestures are best suited for what kind of music. With the use of the DataGlove, for example, they are working on modeling performers' and conductors' actual physical actions and movements.

"People are very used to fooling around with music on their personal computers," Machover says. "But many of them have hit a brick wall in what they can do. Programs soon will be available that, at the very least, will improvise and play along with you. And eventually, users will be able to see their music graphically and holographically—maybe in real time."

Learning with Logo and Legos

Seymour A. Papert, inventor of the Logo computer language, is director of the Learning Research Group. He spends much of his time researching how the computer can offer opportunities for children to acquire knowledge through informal, personal, experimental, and impromptu processes, as opposed to those routine, structured processes they use today.

One learning tool that Papert's group gave birth to is a phonetic dictionary that addresses the common complaint, "How do you look something up if you don't know how it's spelled?" Another and different approach to learning uses Lego building blocks invested with intelligence (via chips) in combination with the Logo language (see photo 6). Papert calls it the Lego/Logo project. With the Logo programming system, Lego building blocks, and an interface between the two, children can learn differently, in a self-initiated process of discovery that previously they would never have considered or thought possible.

The Media Lab's Crystal Ball

Nicholas Negroponte, the Media Lab's dynamic director, takes issue with people who predict that certain things are impossible for personal computers and technology to attain. "There will be a very fundamental change in what personal computers look like," he says. "Today, the PC is driven by the desktop metaphor, but that scenario will disappear and be replaced by a theatrical metaphor. Users literally will see on their screens little *expert agents* who will do things for them."

Negroponte also predicts that we will eventually see three-dimensional images in real time, and that low-cost graphics will explode in the next few years. "CAD/CAM 3-D will move to the desktop. There will be a major turnaround in speech recognition. People will move from direct manipulation of their machines to delegating them as agents.

"MIPS [million instructions per second] and storage have become inconsequential because gigabits per second are speeds that people just can't comprehend. (In 1 gigabit, you can get a year of the *Wall Street Journal* in 1 second.) Symbolic-encoded data will change the whole picture.

"Computers will be *responsive* and will go massively parallel. The relevant question is, how do you use massively parallel machines? As computer chips get a bit more intelligent and start communicating with each other, people won't have to be computer-literate. With the addition of speech and facial expressions, personal computers will offer a sensory-rich experience. Between now and the early 1990s, there will be speech; between the 1990s and the early 2000s, vision will come to our machines." ■

ACKNOWLEDGMENT

My thanks to Patrick Purcell, the Media Lab's director of communications, for the above-and-beyond help he provided for this article.

Janet J. Barron is a technical editor for BYTE. She can be reached on BIX as "neural."

MAKING WAVES

Offspring of the personal computer and ham radio, packet radio has come into its own

Mark Waller

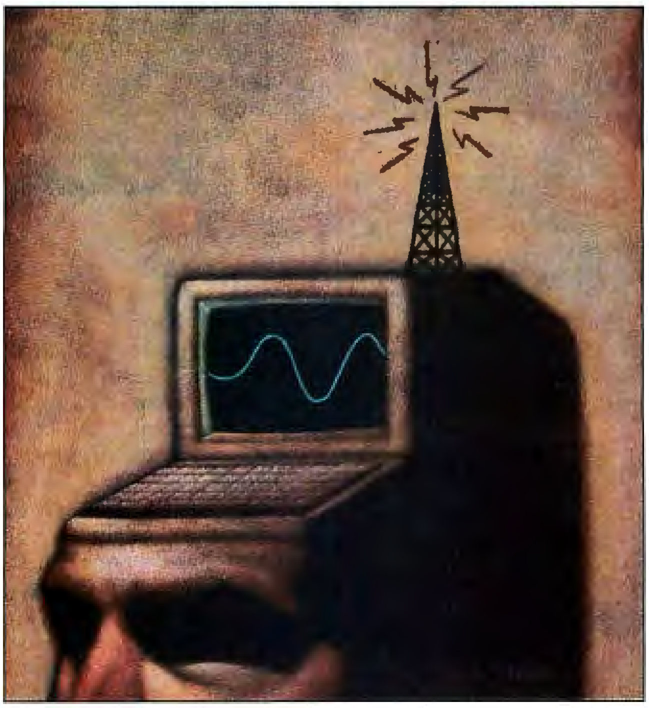
Fifteen years ago, the epitome of the electronics hobbyist was the amateur radio operator. Hams were the electronics innovators, the garage-shop inventors in the forefront of technology.

Then came the microprocessor, and kits that let low-budget tinkerers build their own computers. Suddenly, hams became hackers, and the measure of electronic innovation switched from megahertz to kilobytes.

From the very start, however, the radio and the computer have been natural allies. An article in the third issue of BYTE noted that "marrying the two offers the opportunity to communicate information (of all kinds) on a much wider scale." (See "Computers and Amateur Radio" by Michael A. Gipe in the November 1975 BYTE.)

In the intervening years, as computers took over the technology scene, hams have remained hard at work with their soldering irons in their basements and garages. The result has been a marriage of technologies between the personal computer and the radio. The result: an application called "packet radio."

As the name implies, it's a digital system of transmitting information via ham radios (available only to licensed operators). But this simple concept, along with the ability to exchange data from one station to another, has led to a global network of packet-radio stations. In fact, any packet station can command other packet stations to form a network for the transfer of information. And many networks can operate on the same frequency. So reliable is this new form of communication that American hams sent many packet stations (i.e., computer, transceiver, and packet modem) to their Russian counterparts after the devastating earthquake in Soviet Armenia.



Error-Free Communications

If you've ever listened to amateur radio "QSO" (or conversation), you may have noticed static, noise, and interference from other stations, as well as signals that fade out entirely. Packet-radio pioneers saw the computer as the ideal way to overcome these problems of radio communications.

Packet transmissions consist of small blocks of information called *frames*. There are three types of frames: information, supervisory, and unnumbered (see figure 1). Information frames contain the normal data that one station wants to communicate with another. A supervisory frame provides control of the communications link. Unnumbered frames allow data to be transmitted by one station when there is no destination station. In addition, these frames perform other control functions.

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ILLUSTRATION: TIM TEEBKEN © 1989

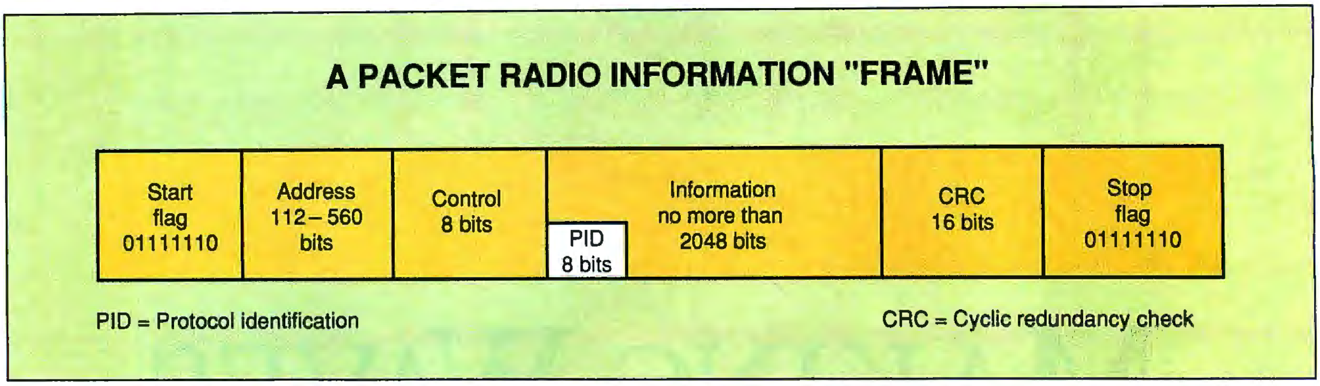

Figure 1: *Packet radios communicate using frames. Each frame is organized using the AX.25 protocol (a version of X.25 modified for amateur radio). Shown here is an information frame; supervisory and unnumbered frames are also used (see text).*

A frame has a protocol of bits arranged as flags, control, and address information. Thus, frames can be sent and received in an orderly fashion, and the communication is complete, logical, and error-free. If the frame sent from one station collides with the frame of another station, or if anything occurs to interfere with the successful reception of the packet, the destination station automatically requests a retransmission and the frame is re-sent.

The Problem of Protocols

As with any new form of communication, packet radio underwent a struggle during the evolution of its universal format. A group of Canadian hams created the first successful packet network. It used start-stop ASCII with the Ethernet CSMA/CD protocol.

Nearly two years later, amateurs all over the U.S. entered the packet world and started work on their own hardware and protocols. Setting up a protocol meant designing the terminal node controller, as well as the way it would communicate. A TNC is the device that actually interfaces between the computer and the radio (see figure 2).

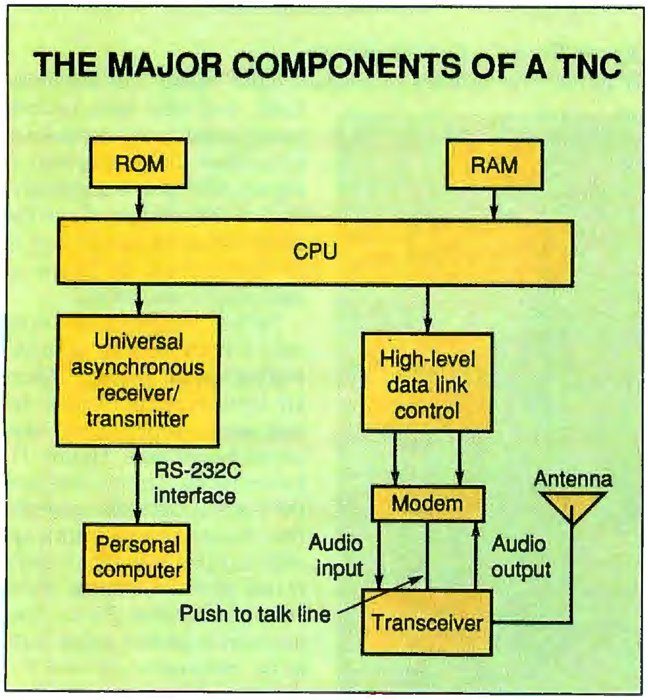

Figure 2: *The terminal node controller (TNC) provides the function of interfacing the computer with the ham radio. It is a device that incorporates the packet modem.*

In late 1981, the Tucson Amateur Packet Radio Corp. came into being and worked on the hardware, while another group, the Amateur Radio Research and Development Corp., worked on the protocol. What came out of all this diligence and cooperation was a microprocessor-based TNC using a resident EPROM that contained the instruction set.

Of course, there had to be a way to transmit this digital signal over the air waves. The packet-radio developers decided to shift the transmitting frequency when a 0 or 1 data bit was being transmitted. Soon, modems with either the Bell 202 or 103 standard could generate the proper digital radio signal.

The Packet Modem

All this experimentation led to a complete packaged product with a lot of features. Creators of the packet modem provided not only full TNC functions using the latest AX.25 version 2 protocol, but also variations of the original that interface to IBM PCs and many other microcomputers. In addition, many products exist that will decode various other digital formats, including fax and Morse code.

If you tune into specific frequencies where packet radio is active, you hear sudden bursts of oscillating tones—one is called the *mark* and one the *space*. The presence or absence of marks and spaces during the packet's short transmission encodes the synchronous bits of information.

Aside from the error-free exchange of data, the real beauty of packet radio is the marriage of the personal computer with the packet modem. You can obtain menu-driven software to control the packet modem and, by implication, the ham radio transceiver. In addition, it's also possible to transfer data on numerous "channels" at the same time. With available software, the operator can control all data transfer and identify which conversation is which as the information scrolls up the screen.

Many stations can share the same packet frequency, and all conversations can appear on the screen, but you can use commands to have the modem show only those packets relevant to the receiving or linked station. Packet stations can link one-on-one or in network fashion.

A packet station can also be used as a *digipeater*—that is, a digital repeater. Two stations can link to a third station to take

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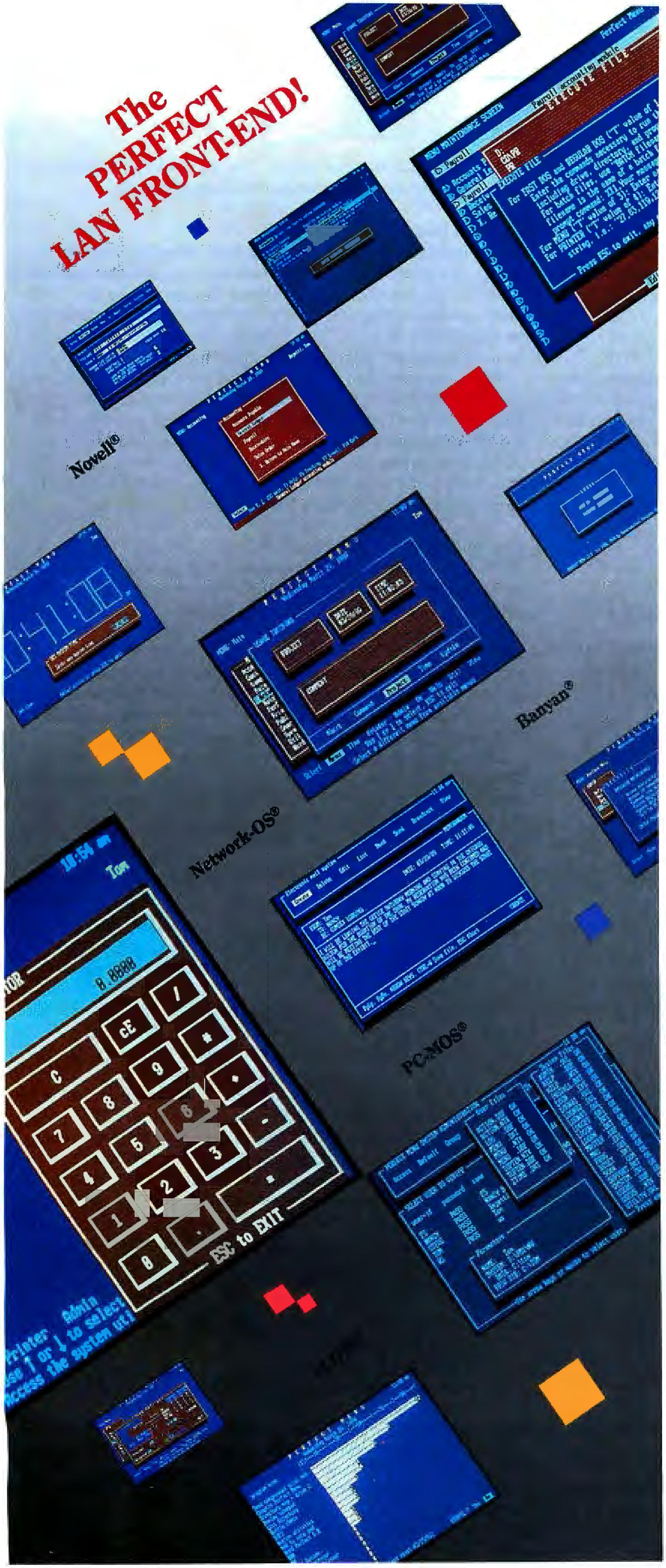

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advantage of its strategic location. For instance, if one station wants to communicate with another but is out of radio range, a third station that both can "copy" can act as a repeater, thereby linking the two stations. This can be done without the digipeater station being in on the exchange of information. It is entirely consistent with the technology for an operator to find his station suddenly being used by two or more other stations to pass information.

Uses for Packet

The digipeater capability allows you to transfer messages over distances much greater than the original transmitting station can cover. Now, for the first time, this networking can take place automatically. As long as several local stations can communicate with one another, an effective LAN exists. Some stations are easier to receive than others because of antenna height variations, intervening mountains, and so forth. By constructing a well-placed repeater roughly in the center of all these stations, operators can substantially increase the reliability of the network communications. Even mobile and portable stations can become part of the network.

Every kind of file that can be transferred by telephone can be downloaded or uploaded via radio.

With packet, a central repeater is not usually necessary. Each station in the network can act as a repeater for any other station it can hear. Nor are networks just local. Today, networks exist that pass messages literally around the world. If you tune a shortwave receiver to around 14.1 MHz, you will hear global message transfers occurring at 300 bps.

Gateways to Other LANs

One or more stations in each LAN can operate as a gateway to other LANs. All that is needed for these special stations is a TNC that has two or more ports and a radio and antenna for each port. An amateur in Los Angeles, for instance, has a reliable communications path into the San Francisco Bay area as well as into Phoenix, and the network of gateways is constantly being expanded.

At frequencies such as 145 MHz, radio signals do not bounce off the ionosphere. They travel straight to the horizon until they bump into a building or mountain. Clearly, networks and gateways are a real advantage in large metropolitan areas. But how would a network user in a 145-MHz LAN pass messages around the world?

The answer is crossband gateways: Packet radio uses short waves that have frequencies with the ability to bounce off the ionosphere and land in distant parts of the globe. Thus, gateways operating simultaneously on VHF (very high frequency, line of sight) and HF (high frequency, shortwave) can pass messages from a LAN in Chicago to a LAN in New York. Nor does it stop there. Today's VHF packet is at 1200 bps, but many stations are experimenting at 9600 bps at frequencies in the 200-MHz and 400-MHz bands. The FCC has authorized experimental stations that operate totally unattended.

Bulletin Boards

Packet technology has blurred the lines between radio hobbyists and computer hobbyists. Software is now available to allow amateurs to run their own BBSes. Operators can use their radio, personal computer, and packet modem to check into numerous BBSes that function as mail centers, file storage and access points, and gateways and nodes in various networks.

When you tune in to one of the many packet frequencies, you may hear more than simple text files being transferred. Every kind of file that can be transferred by telephone can be downloaded or uploaded via radio. And what would be called a special-interest group on a conventional on-line service is handled by a wide array of personal BBSes where hams with specific interests congregate to share files.

Packet Radio—What Next?

The combination of inexpensive portable computers and tiny packet modems has created briefcase-size packet stations. The antenna, a 2-meter (145-MHz) quarter-wave whip, is about 18 inches long and can be fashioned from a coat hanger. The smaller modems (TNCs) are about the size of a pocket calculator. The advent of this technology means that, during a crisis, disaster personnel can set up full-scale communications on a moment's notice by installing packet stations and linking them with established networks virtually anywhere in the world.

Of course, hams have been doing this kind of thing for years. Sometimes they have been the only source of information from the scene to the outside world. Packet radio provides an extra dimension to this scheme. Now, packet-radio modems pass streams of data without waiting for a response, and the data arrives error-free.

Space and the Global Community

During the 1960s, hams designed and built their first communications satellite, called OSCAR (orbiting satellite carrying amateur radio). Its initial launch spawned a ham space program that continued to launch OSCARs.

The next project on the drawing board is PACSAT (packet satellite), a compact flying mailbox. PACSAT will upload messages when it flies by and then download when it is over the receiving station's location. At present, operators can communicate via JO-12 (JAMSAT-OSCAR-12), a satellite successfully launched by the Japanese amateur radio community. Dubbed "Fuji," this satellite has an on-board mailbox system that can store 50 messages in its approximately 192K bytes.

Future projects involve a German satellite, the Space Shuttle, and ongoing packet transmissions that use meteor scatter, the technique of bouncing radio signals off the ionized trails left by space debris as it enters the atmosphere. For the future, the implications of packet radio are awesome. Personal satellite communications will soon become reality. Tomorrow, an operator will be able to carry a small laptop computer/transceiver/packet modem and be in touch with friends around the world.

This kind of immediate, close contact throughout the international community could change our attitudes toward one another and bring the notion of a global community down to a level where all of us are full participants. ■

Mark Waller is a computer facilities consultant and the author of Computer Electrical Power Requirements *and* PC Power Protection *(Howard W. Sams). He can be reached on BIX c/o "editors."*

BIX CALENDAR DECEMBER

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Special Events

THURSDAY, 12/7, 8:30–9:30 PM EST. The case for Ada in CASE.

Does Ada—which was designed to facilitate software engineering—fit in with the latest ideas in CASE? What CASE tools are available for Ada? Hear Randy Brukardt and Dan Stock of R.R. Software answer these questions in their continuing discussion of the Ada language. (join janus.ada/cbix)

SUNDAY, 12/31 and MONDAY 1/1. Send New Year's greetings to your friends.

Once again, this New Year's Eve you'll be able to hoist the electronic glass and bid "Happy New Year" to all your friends on BIX around the globe. And you can do so in two ways: In a special conference called "welcome.90" you can leave permanent messages for people to see as the night progresses. On CBix, our real-time chat system, you can greet and "talk" with other BIXen. But now, let all of us at BIX wish *you* a happy and prosperous 1990.

All-Month Conferences and Special Events

soft.eng conference—How does software engineering for real-time systems differ from traditional software engineering development? What real-time software engineering techniques are adaptable to other types of development? All month, you can discuss these and other questions with experts, in our soft.eng conference. These experts are Dave Franklin, computer science professor at Southern College of Technology and chairman of the IEEE P1073 (Medical Information Bus) Standards Committee; Dana Hudes, a software engineer at Aerospace Avionics and specialist in embedded real-time software; Bob Harbort, associate professor and chairman of the Computer Science department at Southern Tech; and Ron Schroeder, also a computer science professor at Southern Tech and an industry consultant in real-time systems. (join soft.eng/real.time)

IBM Exchange—Every weeknight this month at 10 PM EST, IBM Exchange CBix sessions will address such issues as Borland vs. Microsoft (which of these companies will win our affection in 1990—or will it be someone else?) MIDI on IBM Computers; OS/2 Programming; Assembler Programming. Watch ibm.exchange/info.cbix for the names of special guests, their topics and discussion dates.

Macintosh Exchange—The Mac Exchange will be filled with video and sound this month, as a special guest from LightSource, Inc., joins us for an open discussion of the latest advances in real-time video processing and storage. We'll also be offering gift suggestions to last-minute shoppers for the other Macaholics in their life.

Let The Games Continue—Here's the Interactive Games Exchange schedule for December. Watch for specials, as well:

Sundays, 9PM EST—Poetry, art, music and stories from by-gone days to yet-to-come days are featured in this conference. (join fun.n.games/game.room)

Sundays, 9:30 PM EST—Learn about role-playing games on line and off line at Fantasy Foundation College. (join ff/ff.col)

Mondays, Thursdays, and Saturdays, 9 PM–Midnight EST—Check into the Meade & Mirth Inn and enjoy free-form, role-playing games that take you back to the Middle Ages—and sometimes far into the future. (join mnm/inn)

Tuesdays, Wednesdays and Saturdays, 9:30 PM EST—Enjoy real-time fantasy role-playing games as well as message-based player interaction in Ledinworld, the *Advanced Dungeons & Dragons* center of the IGX. (join lworld/ledinworld)

Thursdays, 10:15 PM EST—Break in on Pandemonium, the contemporary parlor games and other social activities in the "game.room." (join fun.n.games/game.room)

Fridays, 9 PM EST—Begin your T.G.I.F. nights in the pursuit of trivia. (join fun.n.games/game.room)

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ELECTRONIC OXFORD

A five-year computerization effort transforms a massive classic—the Oxford English Dictionary*—into an on-line speedster*

Eric Giguere

The dynamism and adaptability of the English language are evident to anyone who has sat down with a dictionary for an hour of leisurely browsing. As the language evolves, some words fall into disuse, others gain new meanings, and new words are developed to fill the gaps brought about by technological and social change.

Dictionaries are the instruments by which these changes in language are recorded. But dictionaries are out of date as soon as they are published. Computerization offers at least a partial solution to this problem, and few projects have been as ambitious in this regard as the computerization of the *Oxford English Dictionary* (OED).

The Dictionary

The OED is the most comprehensive record of the English language available. As a historical dictionary, the OED's principal goal is to trace both the origins and the subsequent development of English words. Word meanings in the OED are illustrated with extensive quotations drawn from printed sources.

The OED first appeared in installments starting in 1884, and it was finally published in its familiar 12-volume format in 1933. Four volumes of supplementary word definitions, known as the *Supplement*, were added between 1972 and 1986. The 16 volumes contain almost 306,000 main entries and 156,000 subentries.

In 1984, the Oxford University Press (OUP), publisher of the OED, made the decision to computerize the dictionary. Its reasoning was threefold. First, there was the obvious need to integrate the 12 original volumes with the four of the *Supplement*. Second, computerization would allow for efficient and consistent updating of the dictionary in preparation for the release of future editions. Third, OUP also foresaw markets for electronic versions of the dictionary.

The computerization had three stages. First, the entire text of all 16 volumes was transferred to electronic form by International Computaprint in Fort Washington, Pennsylvania; this took more than a year. Then the Centre for the New Oxford English Dictionary at the University of Waterloo in Ontario, Canada, transformed the data into a structured database format and created a set of software tools to manipulate the database. The final phase was integrating the OED with the *Supplement*, a joint effort between OUP and IBM in the U.K.

The integration was finished in late 1988, and a revised edition of the OED was launched in March of this year. The final result is officially known as the second edition of the *Oxford English Dictionary*, a 20-volume set

continued

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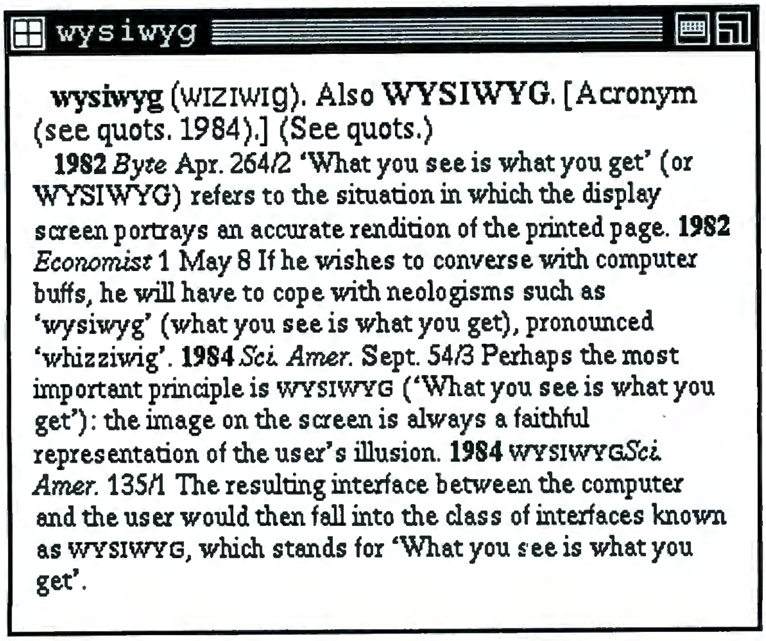
BYTE in the Oxford English Dictionary

Dictionary browsing gains a whole new meaning when applied to the on-line version of the *Oxford English Dictionary*. Since Pat, the software that was used to search the dictionary, can search text and tags, pulling a list of quotations attributed to a specific person or publication is a matter of a line or two of queries and less than a second of search time.

Frank Tompa (one of the directors of the Centre for the New Oxford English Dictionary) and I decided to search for all the entries in the second edition of the OED that included quotations from BYTE. There are 19 such entries: ALU, assembly, backslash, blind, boot, bulletin, CD-ROM, clone, ego, emulator, enable, hacker, lap, log, personal, transportable, user, warm, and, finally, WYSIWYG (see the figure).


wysiwyg

wysiwyg (wɪzɪwɪg). Also **WYSIWYG**. [Acronym (see quots. 1984).] (See quots.)

1982 *Byte* Apr. 264/2 'What you see is what you get' (or WYSIWYG) refers to the situation in which the display screen portrays an accurate rendition of the printed page. **1982** *Economist* 1 May 8 If he wishes to converse with computer buffs, he will have to cope with neologisms such as 'wysiwyg' (what you see is what you get), pronounced 'whizziwig'. **1984** *Sci. Amer.* Sept. 54/3 Perhaps the most important principle is WYSIWYG ('What you see is what you get'): the image on the screen is always a faithful representation of the user's illusion. **1984** WYSIWYG*Sci. Amer.* 135/1 The resulting interface between the computer and the user would then fall into the class of interfaces known as WYSIWYG, which stands for 'What you see is what you get'.

Generated by Lector, the University of Waterloo's display program using X Window, this reference to WYSIWYG is a sample of the dictionary entries produced in the traditional OED format.

Some of these entries are more obvious than others. The entry for *blind* is in an interview article with Dr. James H. Wilkinson, on the building of a computer designed by Alan Turing (February 1985 BYTE, page 190). The phrase that the word is used in is a colloquialism: "You can swear blind. . . ." In a programming maintenance article, there is a reference to "egoless programming" (May 1984, page 420). *Enable* is used simply to demonstrate the phrase "enable the 80-column screen" (July 1986, page 270), and the entry for *user* is a reference in an article on the Lisa computer system to demonstrate the compound word "user interface" (February 1983, page 36).

As might be expected, BYTE is credited in several cases with having the first known published use of a word or phrase. A caption of a listing in an article discussing structured programming in BASIC uses the word *backslash*. "Arguments enclosed in backslashes refer to disk-file operations" (January 1982, page 413). In addition, OED credits BYTE with the first use of *WYSIWYG*—for "what you see is what you get" (April 1982, page 264). BYTE is also referenced as the first user of the word *personal* in the sense of "personal computer" (May 1976, page 90).

that includes the data of the original 16 volumes and about 5000 new or revised entries.

The Centre for the New OED

The computerization of the OED involved more than converting the text into machine-readable form. The dictionary data had to be structured and stored in a database format suitable for the various tasks to be performed, including data integration, consistency checking, entry updating, and general searching. OUP relied heavily on the University of Waterloo for both the technical and theoretical support in this phase of the project.

The Centre for the New Oxford English Dictionary was established in 1985 and is jointly headed by Dr. Frank Tompa and Dr. Gaston Gonnet. They and the other researchers at the Centre developed the theoretical framework for the computerized OED, including several new methods for modeling and searching text data. These theories were then used to create the various software tools needed for the project.

The Centre has taken care to ensure that the software and theories developed for the project are not OED-specific but can be applied to a wide variety of text-dominated databases. (The university owns all rights to the software developed by the Centre; OUP owns the rights to the OED data.) Software is written portably in C, using the X Window System whenever complex display capabilities are needed. The Centre also supports and encourages interdisciplinary research related to the OED and text-dominated databases within the academic community.

Searching the Dictionary

The OED contains close to 540 megabytes of text and tagging information. Tags describe the structure of the dictionary—entries, subentries, etymologies, quotations, and so on—and are patterned after the International Standards Organization's Standard Generalized Markup Language (SGML) tagging style. The tags can be treated as text in certain contexts.

The Centre for the new Oxford English Dictionary developed several software tools to manipulate and search this data. The primary search tool is known as Pat, so named because it uses *Patricia trees*. Pat searches a prebuilt index implemented using Patricia trees and is considered by the Centre's researchers to be one of the fastest search engines available. A price is paid for

continued

New Dauphin LapPRO-386SX Packs a Powerful Punch for the Price

Dauphin Technology, an aggressive new Midwest-based laptop manufacturer, has come up with a high-performance 386SX-based laptop that offers 386 power at a 286 price. The price alone will turn a lot of heads. But a closer look at the machine itself reveals first-rate engineering, exceptional performance, and loads of standard features that would cost extra on most computers.

With a list price of $4,995 and an introductory price of only $3,695, Dauphin Technology has strategically positioned itself to compete head on with rival 286 models in the same price range. Since 386SX technology provides both present and future applications, the choice between a 286 and a 386SX of comparable cost will be an obvious one for many. Users opting for the LapPRO-386SX will have a laptop with more power, speed, memory and versatility along with the technology to serve them through the next decade and beyond.

Among its many prominent features is a 40 M-byte, 28 millisecond hard drive and 2 M-bytes RAM. Its ability to facilitate DOS, multitasking and multiuser functions, plus all the new 32-bit 80386 software makes it a necessity for anyone who requires the power of a high-end desktop model while away from the office.

Last Fall, Dauphin introduced its first laptop model based on an 80286 microprocessor. Though a late-comer to the market, the LapPRO-286 earned considerable praise for combining the most advanced features with quality engineering and price performance.

Both models from Dauphin Tech offer a 40 M-byte, 28 millisecond hard drive, a 3.5″ floppy drive, two serial ports, one parallel port, a high contrast blue on white CGA/EGA LCD, an internal power supply offering four power options including battery pack, and a dedicated numeric keypad. Options include a 2400 or 4800 BAUD internal modem, math co-processor, 100 M-byte hard disk drive, and external floppy drive and keyboard ports.

The LapPRO-386SX sports a processor speed of 16 and 8 Mhz with zero wait states. It offers 2 M-bytes of Ram on board expandable to 4 M-bytes. Its external monitor port supports CGA, EGA and VGA.

Dauphin Technology has priced its 80386SX laptop to compete head-on with rival 286-based models.

Features include:

- 80386SX Processor, 8 & 16 Mhz, Zero Wait States
- Multitasking Capabilities
- Multiuser Access
- 32-bit Software Compatibility
- 40 M-byte, 28 Millisecond Hard Drive
- 3.5″ Floppy Drive
- 2 M-bytes RAM, Expandable to 4 M-bytes
- Internal Modem Option

The LapPRO-286 provides 1 M-byte RAM which is expandable to 4 M-bytes and an 80286 processor running at 8 or 12 Mhz with zero wait states.

Both models offer the highly acclaimed Digital Research Operating System (a.k.a. DR DOS) which is similar to and compatible with MS DOS. The more distinguishing advantages of DR DOS include on-line help, system utilities such as file retrieval, special security features and an ability to embed software in ROM. Alphaworks integrated software and LapLink file transfer software are also included with each laptop.

Judging by its first two laptop offerings, Dauphin Technology could very well be on its way to becoming a major player in the hardware arena. Though Dauphin Technology is relatively new to the computer industry, Alan Yong, founder, is not. In 1981, Yong incorporated Manufacturing and Maintenance Systems which is now recognized as the leading manufacturer and distributor of industrial alignment systems worldwide. The MMS REACT Alignment Systems, used to align rotating equipment in manufacturing plants, employ a proprietary portable computer and software for alignment calculations and maintenance records.

Given Yong's prior experience in portable computer development, the shift toward developing laptops seemed like a natural move. Yong is determined to build another successful company and his determination shows in the design configurations of these first offerings, a promising start.

Distribution channels for Dauphin Tech products are indeed far reaching and ambitious and include dealers, VARs, OEMs (for private label distribution), along with corporate, educational and government sales. The private label arrangement offered by Dauphin represents an ideal opportunity for OEMs to get into the fast-moving laptop market quickly. And the discounts on corporate quantity purchases are so generous that corporate managers of information systems will undoubtedly regard Dauphin as a serious contender for their business.

In keeping with its aggressive sales approach, Dauphin Technology is currently offering an unbeatable introductory price on both models. End-users would be well advised to invest in a high-performance laptop from Dauphin Tech now.

For more information on Dauphin Tech's laptop line, contact Dauphin Technology in Lombard, Illinois at 312-627-4004. And in the meantime, watch for more surprises from this up-and-coming manufacturer.

Circle 100 on Reader Service Card (DEALERS: 101)

this speed, however: The OED index takes up 300 megabytes.

More extensive queries are supported using the Goedel language. Goedel, named for the mathematician Kurt Goedel, can also transform the text in a database, a capability that OUP is using to help prepare a version of the *New Shorter Oxford English Dictionary* from the computerized OED.

The Centre's programmers have written auxiliary tools to complement Pat and Goedel. One of these is Lector, a graphics

Plans are under way to release the second edition of the OED in electronic format.

program currently produced in-house by the University. Lector displays dictionary entries on-screen using X Window in the traditional OED format. The result is a surprisingly simple and responsive system for accessing the dictionary and other large text-dominated databases.

Microcomputer Applications

Plans are under way to release the second edition of the OED in electronic format (on media such as CD-ROM) to the general public sometime in the early 1990s. A version of the original OED came out on CD-ROM in 1988. This version is separate from the work done at the Centre and by OUP/IBM, and its indexing capability is much more limited.

A drawback of current optical and magneto-optical technologies is their slow access times in comparison with magnetic media, a significant factor for a database as large as the OED.

Is there a market for an electronic OED? The OED is unlikely to ever find use as a general-purpose electronic dictionary because of its size and structure. As Tompa puts it, "The OED style of definition would look peculiar in a desktop dictionary." In particular, the OED would be unsuitable for use as a spelling checker; the dictionary is so complete that many common misspellings of current English words are also valid entries. The primary market for the dictionary is likely among researchers in the humanities and the social sciences.

Future Issues

Work on the OED is far from finished. Still to be accomplished is the computerization of the dictionary-making process itself—virtually unchanged since the turn of the century—and a major revision of the OED's style and content. A third edition of the dictionary is expected sometime after the year 2000.

As interest in text-dominated databases grows with the increasing availability of low-cost, high-density mass storage devices, research performed at the University of Waterloo will find other uses as well. Much of the way is already being paved by the NeXT computer and other low-cost workstations. ■

Eric Giguere is a computer science student at the University of Waterloo in Ontario, Canada. He is a freelance writer specializing in the Amiga domain. He can be reached on BIX as "giguere."

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PROTECTED MODE

More memory and safe multitasking—we have seen the future of Intel microprocessors, and it is protected

As the IBM PC architecture reaches the end of its first decade, more and more software products—operating systems and application programs alike—are being rewritten to run in protected virtual address mode (from here on, I'll call it protected mode), an enhanced operating mode available on the 80286, 80386, and 80486 microprocessors.

Most users want to be able to use protected mode for one reason: greater address reach. The older members of the Intel line—the 8088, 8086, 80188, and 80186—are limited to 1 megabyte of address space. (Actually, a hardware developer could decode the status lines on the chips to provide 1 megabyte each of code and data, but the PC BIOS and DOS, which intersperse the two, would not run in this configuration.)

In contrast, the 80286 can access 16 megabytes, and the 80386 and 80486 microprocessors have a potential 4-gigabyte address space—but only in protected mode. When running in real address mode (often called real mode), the mode most commonly used to run DOS, these microprocessors limit themselves to the same 1-megabyte address space as their forebears.

It is, perhaps, a sign of progress that microcomputer users, once happy with the 64K-byte address space of CP/M, now find it necessary to surmount the 1-megabyte address limit of the 8088 and its kin. One method of doing this, the Expanded Memory Specification, will work with even the oldest chips, but it requires cumbersome bank switching. DOS extenders, available only for 80286 and higher machines, let programs access extended memory in protected mode but switch back into real mode when accessing DOS or the BIOS. And operating systems that operate in protected mode (e.g., Unix and OS/2) are gaining popularity because they can easily accommodate larger programs.

There is, however, much more to protected mode than extended addressing. This mode also offers many other powerful features, including multitasking support, virtual memory, protection of key system resources, and software fault tolerance. This month, I'll look under the hood of Intel's protected mode and survey what it has to offer.

Interim Microprocessor

I'll start with a bit of history. When Intel first introduced the 8086, it was known internally as the "interim microprocessor"—the CPU to which 8080, 8085, and Z80 users could upgrade until the iAPX 432 32-bit microprocessor was ready to ship. Thus, a primary 8086 design consideration—one that probably led to much of its success—was that programs written for the older 8-bit microprocessors be easy to port to the 8086. The designers saw to it that there were direct and simple mappings between the old and new register sets, as well as the old and new instruction sets. In fact, they did so well that it was possible to *mechanically* translate 8080 applications into applications for the new microprocessor.

The largest registers (or register pairs) that could be manipulated as a unit on the older architectures were 16 bits wide. Now, while the 8086 had 20 address bits, ported code might have had to be extensively rewritten if address calculations had to be done in a larger register. This is one of the reasons why Intel chose to divide the address into two parts: a 16-bit *segment selector* and a 16-bit *effective address offset* (or logical address).

The 8086 had four *segment registers*, which were used to map the 16-bit addresses used by a program's stack, code, and data into four potentially disjoint regions of the 1-megabyte address space. Figure 1 shows how the 20-bit address that appears on the address bus is calculated: The segment selector from a segment register is shifted 4 bits to the left and added to the logical address to yield the 20-bit *physical address*.

While this architecture doesn't make it easy to manipulate data structures that are larger than 64K bytes, few people had even that much RAM in their systems at the time. It was easy for many programs (and virtually all applications ported from CP/M) to set the segment registers once at the beginning of execution and forget about them. (It might be said that the contents of the segment registers provided "defaults" for the upper bits of every address.)

From then on, the program dealt for the most part—or entirely—with 16-bit effective address offsets, half the size of the addresses manipulated by microprocessors like the 68000. The instruction set was also more compact and didn't require instructions or data to be aligned on word boundaries. As a result, code and immediate data took up about 30 percent less space. In those days, RAM was expensive, a good reason for IBM to choose the Intel architecture over Motorola's for the IBM PC.

The 80286: First Try at Protected Mode

Unfortunately, the iAPX 432—a two-chip, 32-bit Intel microprocessor designed for multiprocessing, multitasking, object-oriented programming, and hardware and software fault tolerance—did not succeed in the marketplace. This may have been because it was too far ahead of its time, or because it was designed to run Ada (which didn't achieve the market penetration Intel thought it

continued

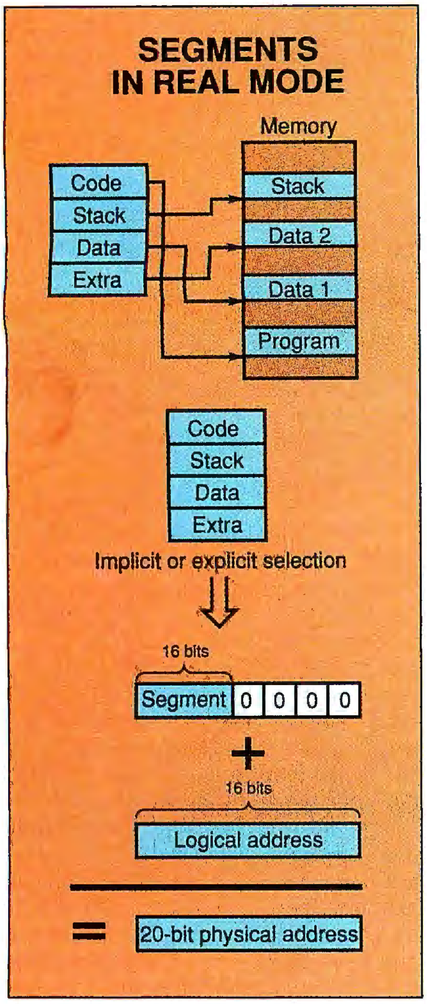


Figure 1: *In real mode, the values of segment selectors have numerical significance. They correspond to the base addresses of regions of memory. The base address is added to the offset to create a physical address.*

would). Or perhaps the chips were simply too expensive.

But the IBM PC and the 8088 *did* succeed—and users clamored for more memory and more processing power to run their existing software. With the 80286, Intel gave them all this and more. As the remainder of this article will show, the 80286 included many features originally implemented in the iAPX 432.

Two features are essential to any system that provides reasonable protection against errant programs and malicious users: *task isolation* and *system resource protection*. The system needs to prevent tasks from mucking about with one another's memory or hogging the system. System resources (e.g., hardware and file system) need to remain under the exclusive control of the operating-system software. Since most resources are accessible through either memory or I/O addresses, the system must maintain control over the way a task accesses them.

Virtual Addressing

The 80286 and its related family of microprocessors come up from a reset condition in real mode. (An exception is the 80376, a protected-mode-only version of the 80386 marketed specifically for embedded systems.) An initialization routine, which executes in real mode, sets up *descriptor tables*, which govern how memory is addressed, and then switches the CPU to protected mode by setting a bit in a control register. (Intel made this transition nearly irreversible on the 80286. The 80386, however, can be brought back to real mode by resetting the same bit. This lets OS/2's DOS-mode session switch modes without literally shutting down the microprocessor.)

In protected mode, there's no longer a simple arithmetic relationship between a segment selector, the offset, and the physical address they refer to. Instead, the microprocessor interposes a special mapping operation between a *virtual address* (the protected-mode segment selector and the offset taken together) and the physical address, as shown in figure 2.

In protected mode, a segment selector is not an addend for an address; instead, it's a "magic cookie," or handle. The selector refers to a *segment descriptor*—a record in memory containing information about the segment, including the segment's *base address*, at which the segment starts. The effective address offset is added to the base address to produce a physical address. (The *selector* pointer for all 80x86 chips is 16 bits wide. The *offset* pointer for the 80286 is 16 bits wide. However, the offset pointer for the 80386 and 80486 is a full 32 bits wide.)

Local and Global Address Space

Each task that runs in a protected-mode system can access segments within a virtual address space that consists of two smaller spaces: its *local address space* and a *global address space* (see figure 3). Code and data objects needed by every task in the system are placed in the global address space, while objects used by a single task go in the local address space. Since a task can't access memory for which it doesn't have a selector, the local address spaces are guaranteed to be private unless a segment is intentionally mapped into two or more of them.

Figure 4 shows the format of a protected-mode selector and the way it's used to find the descriptor of a segment in memory. The upper 13 bits of the selector give the location of the descriptor in an array of descriptors called a descriptor table. (A descriptor is 8 bytes long, so masking out the lowest 3 bits of the selector conveniently forms the byte offset of the descriptor in the table.)

The lowest 3 bits of the selector are control bits. Bit 2, called the *table indicator* (TI), picks one of two possible descriptor tables: the *global descriptor table*, which holds descriptors for segments in the global address space, or the task's *local descriptor table*, which does the same for the local address space.

The remaining bits—1 and 0—are the *requested-privilege-level* (RPL) field. These bits describe the privilege level a task wishes to be granted when accessing

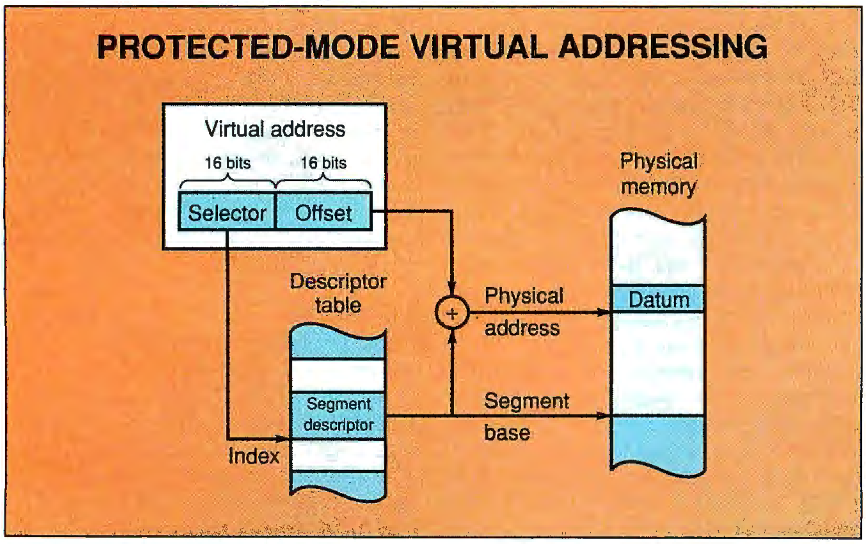


Figure 2: *In protected mode, a segment selector specifies an entry in a descriptor table, which in turn gives the base address of the segment. It also contains the size of the segment (not shown).*

the segment. (I'll have more to say about RPLs later, when I discuss protection and privilege levels.)

Worry-Free Memory Management
Segment selectors and descriptor tables take much of the worry out of memory management. Those of you who program the Macintosh are doubtless familiar with the concept of a heap "handle"—a pointer that must be doubly dereferenced to get at a block of memory allocated on the Mac heap. Because the Mac Memory Manager performs frequent compaction operations, a serious system error can result when a Mac programmer dereferences a handle but forgets to "lock" it.

Protected-mode programming on the Intel microprocessors doesn't open itself to this sort of error. Because a segment selector is, in essence, a handle that appears to be doubly dereferenced during each memory access, segments can be moved about in physical memory invisibly. And since a segment's descriptor is automatically cached within the microprocessor when its selector is placed in a segment register, two address registers are not needed to access the potentially mobile segment. Loading one 16-bit selector does it all.

A protected-mode segment not only can be moved from place to place within physical RAM, it also can be swapped out of RAM entirely. The segment selector/descriptor mechanism lets the 80286 and its kin provide virtual memory without a separate memory management unit. Each segment descriptor contains a bit that indicates whether or not the segment is physically present in RAM, and the microprocessor generates an exception if an application attempts to access a segment that's been purged or swapped out. Thus, while owners of all but the most recent Macs are limited to the RAM they have in their machines (the Mac II provided a socket for an optional, expensive MMU, and the newer 68030 machines have the MMU built in), owners of 80286 machines manufactured as early as 1984 can overcommit storage when running operating systems like Unix and OS/2.

Finally, while it's possible to run off the end of a block of memory allocated on the Mac heap, it's not possible to access memory beyond either end of a protected-mode segment. Each segment descriptor has a "limit" field that gives the exact size of that segment (up to 64K bytes on the 80286, and up to a gigabyte on later microprocessors). An access outside the allowed space causes a *general protection fault*; the operating system

continued

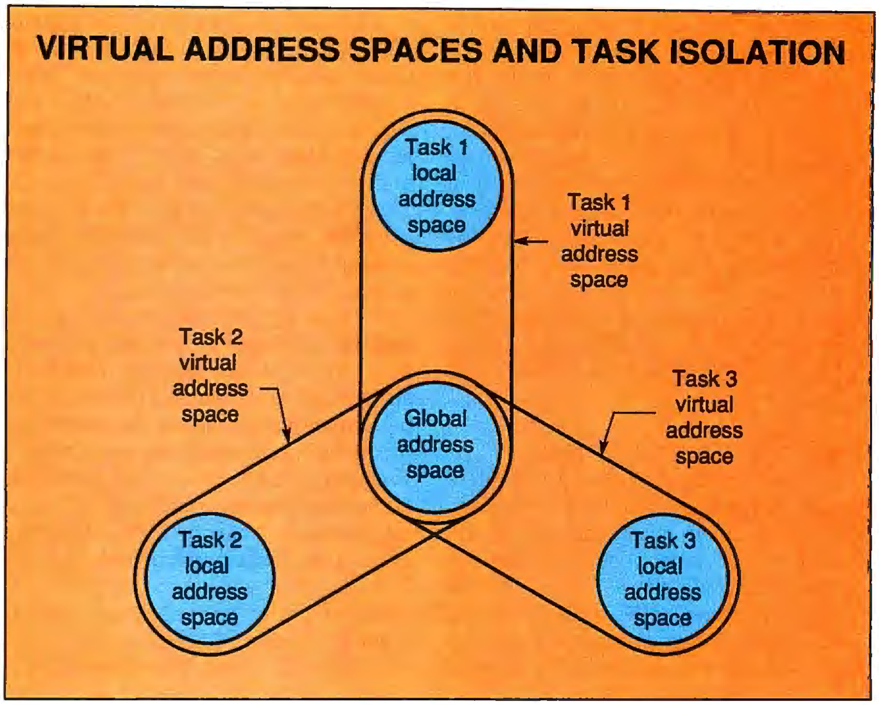


Figure 3: *In protected mode, each task can access a virtual address space consisting of its local address space and the system's global address space. In this figure, the local address spaces are disjoint. However, it's possible for local address spaces to share segments if two local segment descriptors map to the same physical address.*

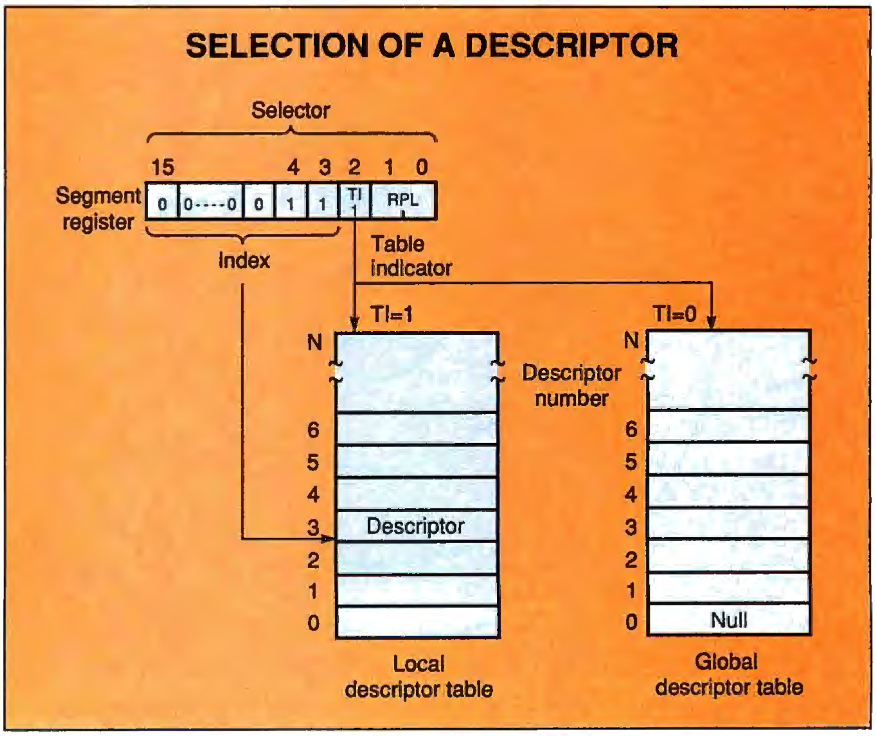


Figure 4: *A protected-mode segment selector has three fields: the index field, which gives the index of the segment's descriptor in the local or global descriptor table; a table-indicator (TI) bit, which tells whether the selector refers to the local or global descriptor table; and the requested-privilege-level (RPL) field, which lets the task restrict its own privilege when accessing the segment.*

gets control and can disable the misbehaving task before it destroys memory.

In some situations, overrunning the end of a segment might not be considered a fatal error. For instance, suppose a task was allocated a 16K-byte stack but happened to need more. If the stack segment is marked as an *expand-down* segment, the operating system can handle an overflow by making the stack larger and then continue the program. (Unfortunately, a mask error prevented this feature from working on the earliest 80286s, so many operating systems, like OS/2, don't take advantage of it.)

Protection: The Onion Model

The hierarchy of privileges and protection in the Intel microprocessors follows the *ring*, or *onion*, model shown in figure 5. There are four possible privilege levels—numbered from 0 to 3, where level 0 is the most privileged. Every task in the system has a *current privilege level*, which is used to determine whether it can do I/O, execute privileged instructions (those that do things like halt the CPU), and/or access segments. Each segment selector also has an RPL field, which a task changes if it wants to have less privilege than its CPL would normally allow when accessing the segment. The *effective privilege level* (EPL) is less privileged than the RPL and CPL, and it determines whether a task can access a segment with a given selector.

Why would a task ever want to give itself less privilege than it might otherwise have when accessing a segment? The answer has to do with something called the Trojan-horse problem. Suppose that a protected-mode operating system has a function called DosRead, which reads information from an open file (OS/2 actually has such a function). The C header of this function happens to look like this:

```
unsigned int pascal far DosRead
(unsigned short FileHandle,
                    void far *PtrBuffer,
                    unsigned int BufferLength,
                    unsigned int far *PtrBytesRead);
```

You don't have to be fluent in C for the purposes of this example; the important thing is that, among the arguments, there's a pointer called PtrBuffer (declared as `void far *PtrBuffer`). The word `void` indicates that the pointer is typeless (i.e., it can point to an object of any type), and the word `far` indicates that the pointer consists of both a segment selector and an offset. PtrBuffer gives the address of the location that's going to receive the data from the read operation.

Now, suppose an application called the function with PtrBuffer pointing to a segment that the application wasn't allowed to access (because it didn't have sufficient privilege). The operating system, which presumably would run at a higher privilege level, would have access to that segment—so the application could, in theory, cause the operating system to read arbitrary data into that place in memory!

To prevent this from happening, the operating system adjusts the RPL field within the selector part of PtrBuffer so that it has no more privilege than the application when accessing the segment. Then, if the pointer turns out to be a Trojan horse, the privilege violation will be caught by the usual protection mechanisms.

All the information about what can be done with a segment—and by whom—is contained in the segment descriptor. Every segment's descriptor has an *access rights byte*, which in turn contains a 2-bit *descriptor-privilege-level* field. The EPL of the task must give it the same or a higher privilege than the DPL for an access to be allowed. The access rights byte also contains other information about what can be done with the segment—whether it can be read or written, for instance, and whether it contains code, data, or a task's stack.

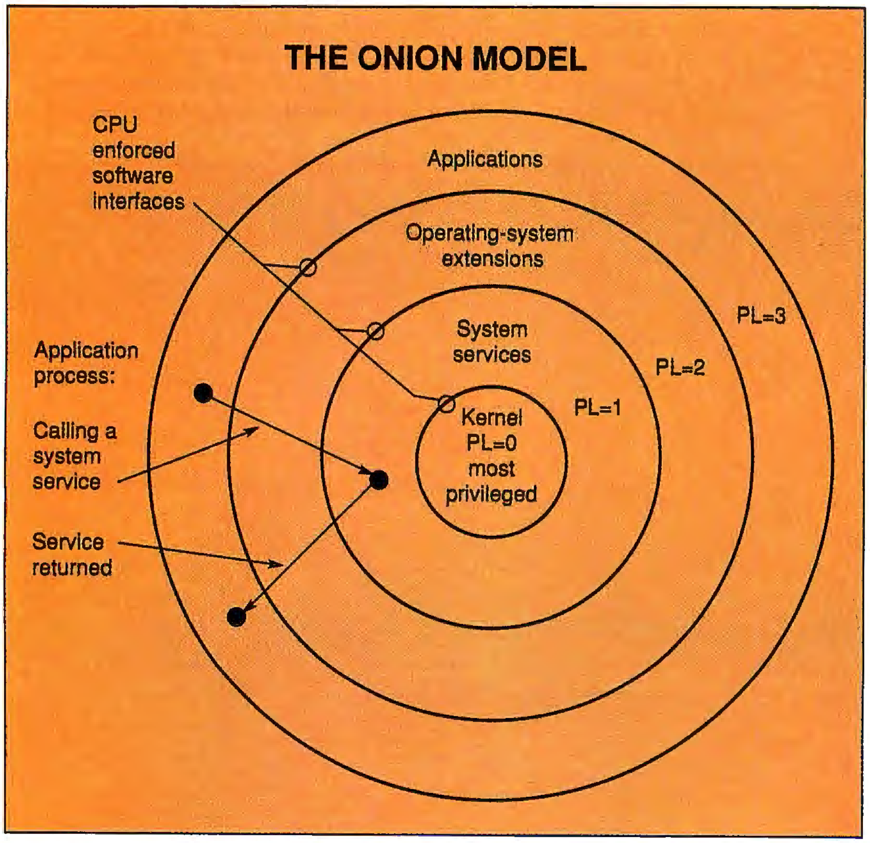


Figure 5: *The four-level hierarchical privilege system used by Intel processors in protected mode is sometimes called the onion model because of the concentric rings. Data stored in a segment with a specific privilege level can be accessed only by a task with the same or a higher privilege, while routines in code segments can be called only by routines with the same or a lower privilege. Thus, only trusted routines can access important data, and less-trusted code can call more-trusted code to perform sensitive operations for it.*

Enter Through Gate 5

A task that's running an application program will probably stay at privilege level 3 (PL 3) most of the time, which means that it cannot access vital system resources. However, a task can jump to a more-trusted (numerically lower) privilege level when it makes an operating-system call via a construct called a *gate*.

Gates isolate less-trusted code—like a user's program, which may be unintentionally (or even intentionally) destructive—from the more-trusted system code that manages system resources. Suppose

a task on PL 3 wants to call a routine in the operating-system kernel, which is running at PL 0. To do this, it makes a call to any address in a segment whose entry in the descriptor table contains a special descriptor known as a *call gate* (see figure 6). This record, in turn, furnishes the CPU with necessary information about the routine, including its address (the application knows only the segment selector) and how many bytes of stack space the parameters take.

You may ask why the gate provides this information rather than the caller. The answer is that the caller can't be trusted not to jump to an erroneous address in the middle of a routine, or even inside an instruction. (This could occur by accident by a buggy program or on purpose by a program with malicious intent.) There's also another reason. Because the operating system can modify the descriptor at run time, it's possible to do dynamic binding (i.e., decide on the fly which routine the call goes to) without modifying the object code of the application. This is how OS/2's *dynamic link libraries* work.

The microprocessor's microcode quickly transfers the parameters from the caller's stack to a different stack at the more privileged level (thereby protecting against stack corruption and overflow) and calls the routine at the address in the descriptor.

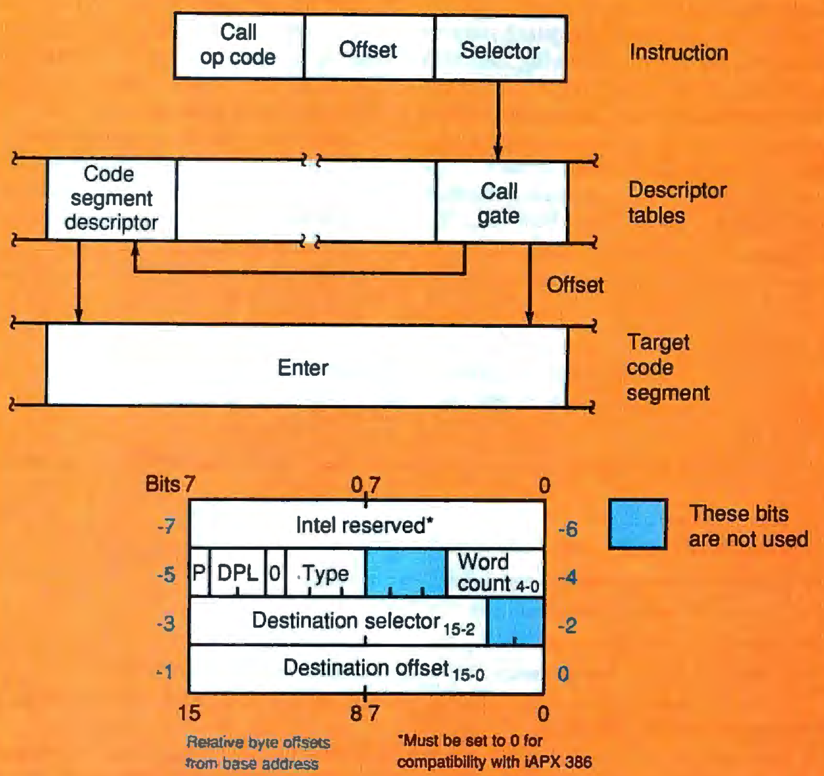
As well as call gates, three other kinds of gates are found in a protected-mode system: *trap gates*, *interrupt gates*, and *task gates*.

Trap gates and interrupt gates are similar in that they can appear only in a descriptor table called the *interrupt descriptor table* (IDT). They're analogous to the entries in an interrupt vector table in real mode (or on other microprocessors) in that they specify the location of the routine that services a hardware or software interrupt, but they contain more information. Since interrupt service routines often need access to the hardware and to privileged instructions, these gates—like call gates—allow an automatic change of stacks and privilege levels during interrupt service.

It's sometimes useful for tasks to share a subroutine that doesn't need any privileges that the caller doesn't already have. In this case, a call gate might be a wasteful way to access the subroutine, since there's no need to swap stacks or check privilege levels. *Conforming code segments* provide a way to do this. When an application calls a routine in a conforming code segment, the CPL doesn't

continued

FORMAT OF A CALL GATE



Gate descriptor fields

Name	Value	Description
Type	4 5 6 7	Call gate Task gate Interrupt gate Trap gate
P	0 1	Descriptor contents are not valid Descriptor contents are valid
DPL	0–3	Descriptor privilege level
Word count	0–31	Number of words to copy from callers stack to called procedures stack. Used only with call gate.
Destination selector	16-bit selector	Selector to the target code segment (call, interrupt, or trap gate). Selector to the target task state segment (task gate).
Destination offset	16-bit offset	Entry point within the target code segment

Figure 6: *A gate controls access to system subprograms by making sure they're entered at the proper point. It also stores protection information and records how the parameters are going to be handled (a transition to a more privileged level will cause a stack switch).*

change; the code executes as if it were part of the application.

Tasks and Task Gates

Protected mode provides explicit support in microcode for multitasking and task switching. Every task on a protected-mode system—or at least one implemented according to Intel's original design—is associated with a *task state segment* (TSS), a large data structure containing the entire state of the machine when it last ran a particular task. (It's accessed as a segment, with a selector, so all the protection mechanisms I've mentioned so far apply to it.) When a task loses control of the CPU, this segment is stuffed with the contents of all the visible and hidden registers necessary to preserve the task's context.

Alas, that's a lot of information. A TSS is always at least 42 bytes long, and a full task switch requires the processor to save at least 28 bytes of status and fetch several more than that to resume the next task. This process is slow, even under the control of microcode. For this reason, OS/2 and even Intel's own iRMX operating system don't use TSSes for most of their task switching; instead, they optimize the process by saving and restoring only what's needed. (A few tricks, including the use of an undocumented instruction called LOADALL, make this technique very efficient.)

Systems that do use the 80286 tasking facilities change tasks by making a jump or call to a task gate, which contains a pointer to the TSS of the task to be invoked (see the text box "A Glossary of Protected Mode"). A task gate can be used not only for time slicing but also for interrupt handling. If a task gate appears in the IDT, it causes the associated task to be activated to service the interrupt. When the task executes an IRET (interrupt return) instruction, control is returned to the task that was running before the interrupt occurred.

Restricting I/O: The I/O Privilege Level

Two bits in the flag word of the 80286 control which tasks can and cannot do I/O. Since being able to perform I/O can let a program directly manipulate the hardware and potentially crash the machine, it's important that only trusted code be allowed to do so.

The I/O privilege-level bits are therefore used to specify the least-privileged level at which I/O can be performed—and also at which certain instructions (e.g., ones that enable and disable interrupts) can be executed. OS/2, for example, sets IOPL to 2, and it comes out of the box configured so that no application program can run at this level. However, because some applications (e.g., debuggers) need to be able to execute these instructions and do I/O, it's possible to configure OS/2 to allow it.

When you specify "IOPL=YES" in OS/2's CONFIG.SYS file, an application can have a code segment called an *IOPL segment* that executes at PL 2. You should be aware, however, that this constitutes a serious breach of system security. A program that can do I/O can program the system's direct-memory-access controller and therefore alter any location in physical memory.

Enter the 80386

The 80286's protection mechanisms are elegant, but the microprocessor itself can still do math only 16 bits at a time. And segments cannot be larger than 64K

continued

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1. Title of publication: BYTE
2. Date of filing: October 1, 1989
3. Frequency of issue: Monthly plus one additional issue in October
3A. Number of issues published annually: 13
3B. Annual subscription price: $29.95
4. Location of known office of publication: One Phoenix Mill Lane, Peterborough, NH 03458
5. Location of headquarters or general business offices of the publisher: McGraw-Hill, Inc., 1221 Avenue of the Americas, New York, NY 10020
6. Names and addresses of publisher, editor, and managing editor: Publisher: J. Burt Totaro—One Phoenix Mill Lane, Peterborough, NH 03458; Editor: Fred Langa—One Phoenix Mill Lane, Peterborough, NH 03458; Managing Editor: Glenn Hartwig—One Phoenix Mill Lane, Peterborough, NH 03458
7. Owner: McGraw-Hill, Inc., 1221 Avenue of the Americas, New York, NY 10020. Stockholders holding 1 percent or more of stock are: Donald C. McGraw Jr.; Harold W. McGraw Jr.; John L. McGraw; William H. McGraw; June M. McBroom; Elizabeth McGraw Webster; all c/o McGraw-Hill, Inc., 1221 Avenue of the Americas, New York, NY 10020. College Retirement Equity Fund c/o Bankers Trust Company, 280 Park Avenue, New York, NY 10015.
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9. Not applicable.
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A Glossary of Protected Mode

call gate A descriptor that gives information on the entry point and parameters of a protected-mode subprogram. It isolates the called routine (which may run at a higher privilege level than the caller) from the code that calls it and guarantees that only the correct entry point is used.

conforming code segment A subprogram in a conforming code segment runs at the same privilege level as the task that calls it. A conforming code segment is also the only kind of code segment that can be read directly as data. Conforming code segments are useful for utility routines and for the storage of read-only static data.

current privilege level (CPL) The privilege level of the code segment that a task is currently executing.

descriptor privilege level (DPL) A field within a descriptor that determines the least privilege a task must have to access the associated segment.

descriptor table An array of 8-byte records called descriptors, which in turn contain information about segments (e.g., base address, size, and privilege).

effective address offset The offset from the beginning of a segment where the desired data lies. In protected mode, only the offsets of variables bear a known numeric relationship to one another. The values of segment descriptors don't correspond to the locations of segments in physical memory.

effective privilege level (EPL) When accessing a particular segment, this is equal to the lesser of the task's privilege and the requested-privilege-level field of the segment selector.

expand-down segment This can be used for a stack that may grow to a larger size than originally anticipated. Stacks grow downward on the Intel processors. If the stack pointer drops below the bottom of the space allocated for the segment, the processor generates an exception, and the operating system can decrease the minimum allowable offset into the segment. (This feature did not work on some early 80286 chips; the contents of the CX register were lost when the exception was generated.)

expand-up segment This works like an expand-down segment, but it can grow upward rather than downward (i.e., the maximum offset can be increased). While not useful for the processor stack, this kind of segment can be useful for high-level-language stacks that grow upward (as in BCPL, a precursor to C) or when the total amount of data space that is used by a program is unknown.

global descriptor table (GDT) This table stores the descriptors of segments that are potentially accessible by every task in the system (subject to privilege constraints). The GDT is a segment itself, containing a self-referential segment descriptor; it also contains descriptors for the local descriptor tables of all the tasks in the system.

interrupt descriptor table (IDT) This table contains descriptors (i.e., task gates, interrupt gates, and trap gates) for the routines that handle hardware interrupts, software interrupts, and exceptions.

interrupt gate A special descriptor, found in the interrupt descriptor table, that gives information about an interrupt service routine. It's identical to a trap gate, except that interrupts are disabled when the service routine is entered.

local descriptor table (LDT) A task's LDT contains descriptors for segments accessible to that individual task (but not necessarily to any other task in the system).

paged virtual memory This lets programs access more memory than is actually present on a given machine. Data is swapped to and from a disk in 4K-byte pages as needed. Only the 80386 and the 80486 implement paged virtual memory; the 80286 offers only segmented virtual memory, in which whole segments (as long as 64K bytes) are swapped.

protected virtual address mode Also called protected mode, this is the mode of the Intel processors in which addresses are virtual (i.e., the numerical value of a pointer's segment selector doesn't correspond to any fixed physical address) and not all tasks can access all parts of memory.

real address mode Also called real mode, this is the mode of the Intel processors in which there is no memory protection and there is a direct arithmetic relationship between segment selectors and physical addresses in memory. The 8088 and 8086 are capable of only real-mode operation.

requested privilege level (RPL) The RPL field of a segment selector lets a task lower its privilege when accessing a particular segment. This feature is used to prevent Trojan horses (see the text).

segment descriptor A record that describes the location of a segment in physical memory, as well as its size and how it can be used.

segment selector A "handle" that designates a particular segment. It contains an index into the local or global descriptor table of a task, as well as a requested privilege level.

task gate This lets one task invoke another. A call to a task gate causes a complete processor context switch.

task state segment (TSS) The processor stores information about a task here. When the task is not running, the TSS holds the complete processor context (e.g., the values of registers and the location of the task's local descriptor table) necessary to reactivate the task.

virtual 8086 mode This mode lets the 80386 and 80486 run programs designed for real-mode operation when the processor is in protected mode. A real-mode program running in virtual 8086 mode is given access to a limited address space that "appears" the same as the 8086's 1-megabyte address space; in fact, this space is mapped into the 4-gigabyte protected-mode address space by the paging unit.

bytes, which means that an application that uses much memory spends a great deal of time loading and reloading segment registers. (Since loading a selector into a segment register also causes the descriptor to be fetched, this apparently simple register operation actually incurs substantial overhead.)

The 80386 therefore added 32-bit general registers, 32-bit math, and segments with 32-bit offsets, while retaining the ability to run 80286 code. (Segment selectors in the 80386 and 80486 are still 16 bits long, so pointers in 80386 protected mode occupy 48 bits, or 6 bytes.) The 80386 also included several new addressing modes. Some of these modes use a barrel shifter to facilitate array access; if the components of the array are 2^n bytes long (where n is an integer), the subscript can be put directly into a register and will be shifted automatically before being added to the starting address of the array.

The 80386 also implements *paged* virtual memory. Unlike the 80286, which can swap only whole segments in and out of memory, the 80386 can swap chunks of memory in increments of 4K bytes. This finer granularity means that there's likely to be less of a wait during a swap; also, the operating system isn't required to shuffle memory to free a contiguous block of memory for a large segment.

Finally, the notion of I/O privilege was expanded in the 80386. Instead of making a blanket prohibition on I/O for tasks that execute without a sufficient amount of privilege, the 80386 lets the operating system create an *I/O permission bit map* that specifies, port by port, which I/O addresses a task can access.

These niceties, however, are generally of interest to systems programmers and compiler writers. Users—concerned primarily with address reach and downward compatibility—appreciate two features the most: 32-bit addressing and virtual 8086 mode.

Big Segments, and More of Them

The 80386's segments can contain up to a gigabyte of memory each—more memory than many microprocessors are able to address. Therefore, the 80x86 instruction set, which is optimized for programs that have one code segment, one data segment, and one stack segment, can be used at maximum efficiency.

Also, besides the set of segment registers included in the earlier Intel processors (CS, DS, ES, and SS), two new ones have been added: FS and GS. These changes reduce the overhead of loading segment registers to a bare minimum for virtually all applications.

However, the same basic protection rules apply in the same ways, so code doesn't need to be modified much to take advantage of the new architectural features. And since each code segment can be marked as using 16- or 32-bit registers by default (by setting the appropriate bits in the segment descriptor), 80286 code can run concurrently with 80386 code on the same machine.

Virtual 8086 Mode

No one likes to throw out software, especially when you have paid hundreds or even thousands of dollars for it. Unfortunately, the best and most powerful software currently available for the Intel microprocessors runs under DOS and cannot be run in protected mode. OS/2's DOS-mode session lets one (and only one) DOS application be run at one time together with the protected-mode operating system, since the memory accessed by the real-mode program must actually be at the physical address that the program expects.

Furthermore, the real-mode application must be "frozen" unless it has almost complete control of the hardware, including the display. This means that protected-mode programs can run in the background while the DOS-mode session is in the foreground, but not the other way around. Finally, compatibility is not complete. Many programs just won't run in the DOS-mode session due to quirks or memory limitations, and this deters users from switching to OS/2.

The 80386 and 80486 get around this problem by letting tasks run in virtual 8086 mode. In this mode, protected-mode virtual addressing (i.e., descriptor tables, and so on) is turned off, and the 8086 program "thinks" it's running in a 1-megabyte address space where segment selectors have the same arithmetic relationship to physical addresses as they do in real mode.

In reality, however, what is going on is quite different. The 80386's paging hardware is used to map each 4K-byte chunk of that 1-megabyte address space to any 32-bit address in physical (or virtual) memory. This means that multiple virtual 8086s can run at the same time, since none needs access to the "real" address 0. It also means that several virtual 8086 tasks can share a single copy of a real-mode operating system. Finally, none of the virtual 8086 programs can "see" memory that isn't mapped into their address spaces, which guarantees that system security remains intact.

What if a program running on a virtual 8086 wants to do I/O? The result depends on the I/O permission bit map for that task. Any I/O operation that needs to be caught and simulated can be trapped simply by denying the task access to a port. An attempt to do I/O causes the operating-system software that manages the virtual 8086s (usually called a virtual machine monitor) to gain control; this monitor can then take whatever action it deems appropriate.

Putting It All Together

As complex as it all may sound, protected mode provides only a basic framework for an operating-system environment. It takes a lot of ingenuity to apply these concepts to the design of an operating system.

What protected mode does, however, it often does embarrassingly well. Many programs that were assumed to be quite sound have shown major flaws when run with protected mode's strict checks on pointer validity. And environments like IGC's VM/386 can run independent virtual 8086s that are so well isolated that you can literally crash and reboot them individually.

Intel isn't saying much about what direction the 80586 and future microprocessors will take, but it's clear from current trends that the protected-mode architecture won't be retired any time soon. ■

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ACKNOWLEDGMENT

Thanks to Intel Corp. for the use of some figures used in this article. Thanks also to Gordon Letwin and Anthony Short of Microsoft for their help with some of the subtler points of protected mode.

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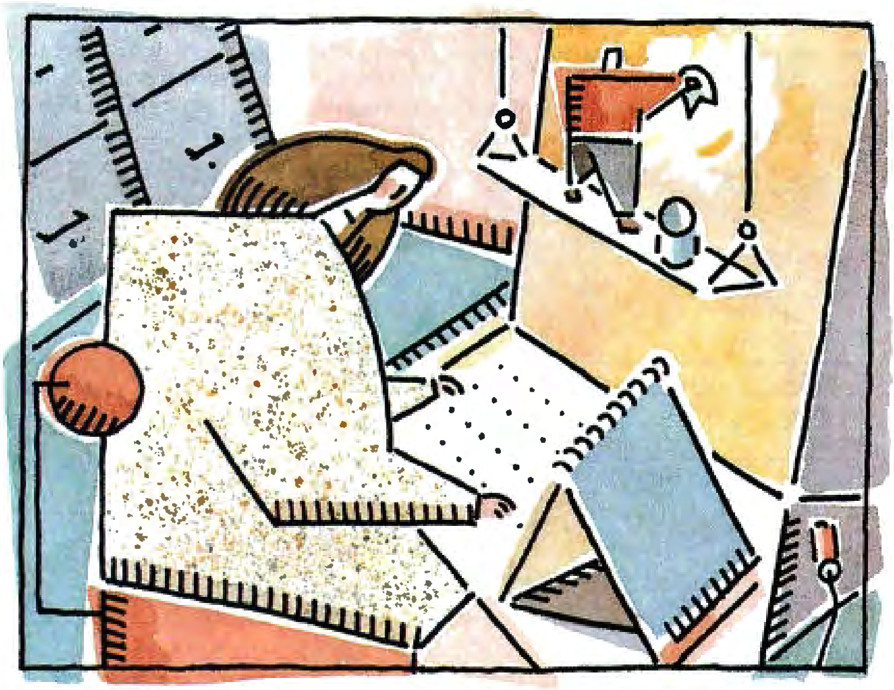
A data-entry TSR program and how to use it from six different compiler/interpreters



I got my best lesson in user interfaces while watching a secretary enter a client's name into a field clearly marked "current balance." She was reading from a printout, so she wasn't paying attention to the screen. As she typed, the characters of the client's name escaped the boundaries of "current balance" and overwrote a portion of the neighboring field.

The screen looked pretty messy when she'd finished, and she told me so when she finally looked up from the printout and saw what she'd done. It wasn't her fault, it was mine. *I* had written the program, and it was obviously lacking in safeguards.

This seems like a small thing, doesn't it? Nothing crashed, so no harm done, right? Wrong. You and I know that the program wasn't trashed, but a user might not. A trashed screen can undermine the user's faith in an application, which spells the difference between a program that sells and one that doesn't.

Even I am occasionally waylaid by this problem. While I'm typing information into a data-entry screen, the phone rings and I hastily put my stack of papers down to answer it. What I don't notice is that my papers rest on an edge of the keyboard, and by the time I've returned, an army of *a*'s has conquered the lower third of the screen. If the program doesn't have a screen redraw capability, I've got to abort and restart it.

Sometimes the results of inadvertently entering improper information for a field can be more than a disfigured display. In C, you typically use the `scanf()` function to translate input strings into the internal representations of floating-point numbers, integers, and so on. If `scanf()` encounters an alphabetic character when it's expecting a digit, it aborts the scan. The contents of arguments whose values were not successfully input remain unchanged, which in this case is another way of saying "random." Although `scanf()` returns the number of successful conversions, some programs don't check this return value. The results are at least unexpected and at most spectacular.

BASIC programmers will recognize this as the famous "?Redo from start" problem—that cryptic message being what most BASIC interpreters respond with if you enter a text string at a prompt that expects numeric input. When this happens, BASIC reissues the input prompt and you get to try again. It's a mixed blessing: The program doesn't bomb, but any orderly data-entry screen you may have painted is usually mucked up by the error message. I suppose the message comes from the fact that if you enter improper data for *any* argument in a multivariable INPUT statement, you have to reenter all the values—even those you got right. Thus, for example, if the BASIC statement is

```
100 INPUT A,B,C
```

and you enter

```
1,2,HELLO
```

even though BASIC gagged only on "HELLO," you've got to reenter the whole line.

I See the Light

This was a speed bump that I hit no matter what language I programmed in. I needed input formatting at the time the

continued

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input was taking place, not after the user had hit the carriage return. Finally, while employed as a programmer a few years ago, I saw what I thought was the best antidote on a Qantel minicomputer.

Qantel used semi-intelligent terminals to which the programmer could download an input template that controlled the location and type of input data. Thus, you could tell the terminal, "Allow the user to enter a 10-digit number here, a 30-character string over there, and a nine-digit floating-point number down there." The terminal did input filtering locally. Users simply could not enter a non-number in a numeric field; if they tried, the system would beep and refuse to echo the character.

Qantel's input template approach had three benefits going for it. First, it neatly handled the problem of the user entering the wrong type of data. If the cursor was in a field defined to be numeric, the computer would accept only digits, a decimal point, or plus and minus signs.

Second, it gave the user some feedback regarding the precision of a numeric field. For example, say your program has defined an input variable that was used as a percentage, but this variable was expected to be integer only. On a system without input formatting, you might enter 15.95 only to see that figure show up later on some report as 16 (or, if you've used truncation, 15). Using the input template approach, your program could define that percentage field as being integer only, and the terminal would have refused to accept a decimal point.

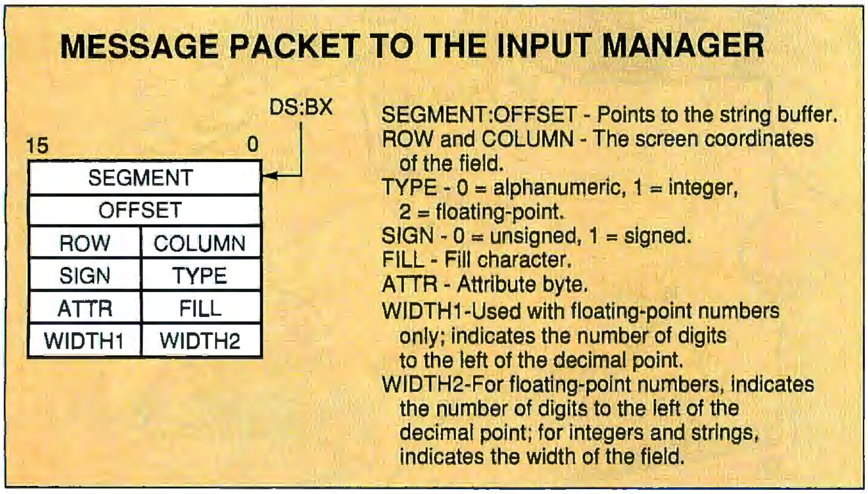

Figure 1: *Requests to the IMAN TSR program include a reference to a message block. The first two words point to the location of the string buffer. The rest of the structure describes the attributes of the data-entry field.*

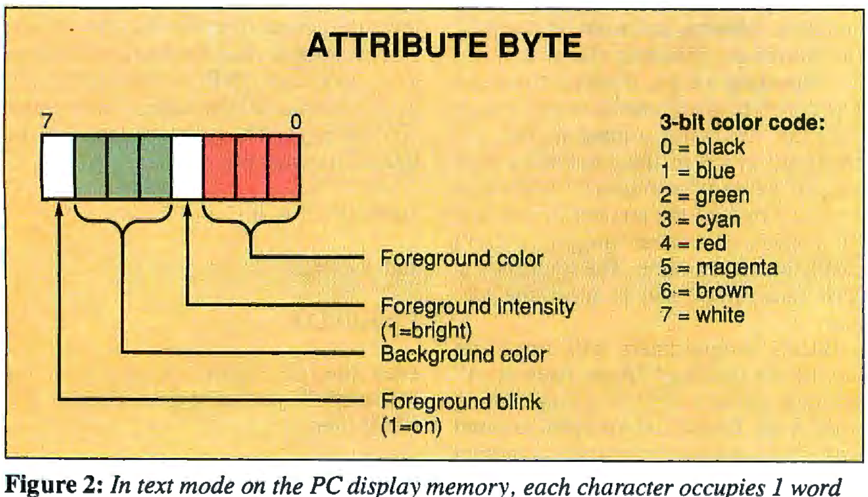

Figure 2: *In text mode on the PC display memory, each character occupies 1 word of screen memory: 1 byte for the character and 1 byte for the attribute (the character's color and enhancements). Different types of displays use the attribute byte differently.*

Finally, the input handler kept all numbers right-justified. As the user typed digits in, they scrolled to the left, as on a calculator's display. So your program could define a column of numbers, and all the decimal points would line up. Your program could total that column and keep the dollars over the dollars and the cents over the cents without having to redisplay the figures. This resulted in orderly looking displays that the sales people were particularly fond of showing off at demonstration time.

After I'd moved from minicomputers to microcomputers, I was determined to bring that kind of input formatting along with me. Most of my early work on microcomputers was in interpreted BASIC on CP/M machines, so I strung together a machine language USR routine that was a good substitute for the input template. Now I figure it's time to bring it over to the MS-DOS world.

IMAN to the Rescue

The input manager (I'll call it IMAN) gives you the ability to define formatted input fields on-screen. I've tried to make IMAN as language-independent as possible. IMAN is a TSR program. Executing IMAN.EXE installs the input manager at interrupt 62H and returns to DOS. Consequently, you can use IMAN with interpreters as well as with compilers; you don't have to link IMAN into your application. (Aside: This is not a new use for TSR programs; other packages use this technique so they won't be tied to a particular language. NetBIOS and Btrieve are two good examples.)

Your program sends requests to IMAN via a *message block.* The format for this block is shown in figure 1. In most languages, this block will simply be an array of integers. (I'll give sample call and return interfaces for six popular compilers and interpreters later.) IMAN expects the offset to this array in the BX register, and the array's segment in the DS register.

The first 2 words (each word is 2 bytes) of the message block are the segment and offset to a string buffer. This is where IMAN will put the user's input. Depending on what language you're using, the string buffer will be either a character array or a string in the caller's program. If there's any data in the buffer when you call IMAN, the routine will display it and allow the user to edit the data. So you can use IMAN for data editing as well as data-entry displays.

The next word holds the screen coordinates of the input field. The coordinates

are in row/column form, with the low byte holding the column and the high byte holding the row.

The word following the screen coordinates is likewise divided into 2 bytes. The value of the low byte indicates what kind of data IMAN will allow the user to enter: alphanumeric, integer, or floating-point. The high byte pertains only to numeric fields and should be set to either 0 or 1. A 0 indicates that the field is unsigned—IMAN will not allow the user to enter a "+" or "−" character—while a 1 denotes a signed field.

The low byte of the next word holds the fill character. IMAN displays fill characters for vacant portions of the entry field. Typically, you'll use the underscore character for a fill character, so the user can instantly tell how wide the entry field is. The high byte is the attribute byte, which controls the color and intensity of the foreground and background for each character in the entry field. See figure 2 for a layout of the attribute byte.

Finally, the last word controls the field width. For alphanumeric and integer fields, the low byte determines the field width. For floating-point fields, the high byte indicates the number of characters to the left of the decimal point, and the low byte indicates the number of characters to the right.

Since IMAN returns its results as a string, it's up to the calling program to convert that string to its actual value. I didn't want to burden IMAN with ASCII-to-integer and ASCII-to-floating-point routines; support for that would be in the language of the calling application, anyway. In C, you'd use the `sscanf()` function; in BASIC and Pascal, you'd use the VAL() function; and in Modula-2 you'd use the `StrToInt()`, `StrToCard()`, or `StrToReal` functions.

IMAN expects and returns null-terminated strings, which causes some difficulties for languages that precede strings with a length byte. In the upcoming examples, you'll see that this is easy to deal with.

Turbo C

Calling IMAN from Turbo C is easily handled by the routine shown in listing 1. The character array `imbuf` holds the null-terminated string that the user types in. Notice that I return the length of the string as the function value. This makes it easy for a calling application to determine whether the user actually entered anything.

The toughest trick to pull off is determining the segment and offset address of

continued

Listing 1: *Calling IMAN from Turbo C.*

```
#include <stdio.h>
#include <dos.h>
char imbuf[80];
/*
** Interface to IMAN. Assumes a global character
** array called imbuf. The contents of imbuf should
** be terminated with a null.
*/
int
calliman(imrow,imcol,imsign,imtype,imattr,imfill,imw1,imw2)
unsigned int imrow,imcol;    /* Screen coordinates */
unsigned int imsign;         /* Sign control */
unsigned int imtype;         /* Format type */
unsigned char imattr;        /* Attribute byte */
unsigned char imfill;        /* Fill character */
unsigned int imw1,imw2;      /* Field widths */
{
    unsigned int immes[6]; /* Message */
    struct REGPACK cpuregs;

    immes[0]=FP_SEG((char far *)imbuf);
    immes[1]=FP_OFF((char far *)imbuf);
    immes[2]=(imrow<<8) | imcol;
    immes[3]=(imsign<<8) | imtype;
    immes[4]=(unsigned int)(imattr<<8) | imfill;
    if(imtype!=2) imw1=0;
    immes[5]=(imw1<<8) | imw2;

     /* Load the cpu registers */
    cpuregs r_ds=FP_SEG((unsigned int far *)immes);
    cpuregs r_bx=FP_OFF((unsigned int far *)immes);

     /* Call IMAN */
    intr(0x62,&cpuregs);

     return(strlen(imbuf));
}
```

Listing 2: *The Turbo Pascal interface to IMAN.*

```
USES DOS, CRT;

VAR
    IMBUF: STRING[80];

{ This function calls IMAN. It expects that you've already
 defined a global string named IMBUF. }

FUNCTION
CALLIMAN(imrow,imcol,imsign,imtype,
    imfill,imattr,imw1,imw2: INTEGER) : INTEGER;
VAR
    pcregs: REGISTERS;
    IMMES: ARRAY[0..5] OF INTEGER;

BEGIN
    IMBUF:=IMBUF + #0;    { Append a null }
    IMMES[0]:=SEG(IMBUF);  { Segment }
    IMMES[1]:=OFS(IMBUF)+1; { Offset }
    IMMES[2]:=(IMROW SHL 8) OR IMCOL;
    IMMES[3]:=(IMSIGN SHL 8) OR IMTYPE;
    IMMES[4]:=(IMATTR SHL 8) OR IMFILL;
    IF IMTYPE<>2 THEN IMW1:=0;
    IMMES[5]:=(IMW1 SHL 8) OR IMW2;

    { Set up registers }
    pcregs.BX:=OFS(IMMES[0]);
    pcregs.DS:=SEG(IMMES[0]);

    { Call the interrupt }
    INTR($62,pcregs);

    { Fix the returned string }
      IF POS(#0,IMBUF)=1 THEN
       CALLIMAN:=0
      ELSE
       BEGIN
        IMBUF:=COPY(IMBUF,1,POS(#0,IMBUF)-1);
        CALLIMAN:=SIZEOF(IMBUF);
       END;

END; { CALLIMAN }
```

the string buffer and the message array. (You'll see that this is true for the other languages as well.) Turbo C provides two macros, FP_SEG and FP_OFF, that return the segment and offset components, respectively, of a far pointer type. Since `imbuf` is an array, and since there's no telling what memory model the final application will be running in, you've got to use coercion—hence the `(char far *)` prefix.

Once the message's contents are properly loaded, you call Turbo C's `intr()` function, which in turn calls IMAN's interrupt. The first argument to `intr()` is the interrupt number, and the second is the pointer to a structure of type REGPACK (which is defined in the `dos.h` include file). You can set the contents of the CPU's registers at the time of the interrupt call by storing into the elements of the REGPACK, and it holds an image of the registers' states when the interrupt routine returns. Since IMAN terminates the string with a null prior to returning to the calling program, the contents of `imbuf` are C-compatible.

Turbo Pascal

In listing 2, you'll find the Turbo Pascal interface to IMAN. The main difference between how Turbo C and Turbo Pascal handle the call to IMAN—beyond the fact that they are two different languages—springs from the differences in how each language handles strings. In C, a string is an array of characters terminated by a null. In Pascal, a string is an array of characters preceded by a length byte. Since IMAN handles strings in the fashion of C, you've got to do some front-end and back-end work.

In listing 2, you can see that I've loaded the array element IMES[1]—where IMES[] holds the message block—with the offset of the string buffer plus 1. In this way, the offset passed to IMAN points to the first character of the string, not its byte count.

Setting the CPU registers in Turbo Pascal looks notably similar to Turbo C's method. Only the nomenclature is changed: C uses structures, while Pascal uses records. Even the name of the procedure call is the same: INTR().

Once IMAN returns, you've got to purge the trailing null character from IMBUF. Otherwise, the VAL() function, which is Pascal's counterpart to C's `scanf()`, will refuse to convert numeric entry. I accomplished this with Pascal's COPY() function, copying IMBUF on top of itself, excluding the final null character. The net effect is to decrement IMBUF's length byte.

GWBASIC

Deriving a working interface to IMAN for GWBASIC requires some programming gymnastics that, if properly accomplished, will really impress your friends. Deep Thought says it best: "Tricky." See listing 3.

To make it through this maneuver, you need to rely heavily on GWBASIC's USR function, which allows your program to call a machine language subroutine. A USR function accepts one argument, which is made available to the subroutine in a field referred to as the FAC (for floating-point accumulator). Fortunately, GWBASIC sets the BX register to point into the FAC. The subroutine can send back an integer to the calling BASIC program by placing a value into the FAC prior to issuing a RETF instruction.

My first USR routine appears in lines 50000 through 50005, where I'm using a three-element integer array (IMCAL%) to hold a short, three-instruction machine language routine that moves the DS register to the location pointed to by the BX register and then returns. The VARPTR(IMCAL%(0)) statement returns the address of the first variable of that array, which, in this case, is the beginning of the machine language subroutine. The end result is that the contents of the DS register show up in the variable BASDS%. You'll see why I need the DS register momentarily.

The actual call to IMAN takes place starting at line 51000, where I redefine the USR function to point to another short routine consisting of

```
MOV   BX,[BX] ;Get the integer
                argument
INT   62H     ;Call IMAN
RETF          ;Back to BASIC
```

Then I load up the array IMMES%() with the message information that IMAN expects. Here's where I use BASDS%; since that variable holds the value of GWBASIC's DS register, it is therefore the segment address of the string buffer that IMAN uses to capture the user's input. (Since GWBASIC keeps all data in a single segment, the DS register on entry to IMAN is set to the same value as in BASDS%, so you may be wondering why I bothered putting DS into BASDS% in the first place. The reason is that IMAN doesn't know who is calling, and therefore doesn't know that the caller's DS is the same as the string buffer's segment.) Once IMMES%() is properly set up, I execute the USR() function, which transfers to IMAN.

When IMAN returns, the input string is in IMBUF$, terminated by a null. It's a simple matter to determine the string's length with an INSTR() function. If the input was numeric, you use VAL() to convert it from characters to a usable number.

It's important to note that VARPTR can be a tricky function, particularly if you use it in conjunction with arrays and

continued

Listing 3: *Calling IMAN from GWBASIC.*

```
5 DEFINT A-Z
9 'Dimension stuff for IMAN
10 DIM
IMCAL%(3),IMMES%(6)
15 GOSUB 50000 'Initialize IMAN
 ...Your program goes here...
49999 'Determine BASIC's DS register
50000 IMCAL%(0)=&HD88C:IMCAL%(1)=&H789:IMCAL%(2)=&HCBCB
50005 BASDS%=0:DEF USRO=VARPTR(IMCAL%(0)):BASDS%=USRO(IMCAL%(0))
50009 'Build routine to call IMAN
50010 IMCAL%(0)=&H1F8B:IMCAL%(1)=&H62CD:IMCAL%(2)=&HCBCB
50015 IMBUF$=STRING$(80,0) 'Build buffer
50020 RETURN
50099 'Entry point to IMAN
50100 IMMES%(0)=BASDS% 'Segment
50104 IF LEN(IMBUF$)<80
 THEN IMBUF$=IMBUF$+STRING$(80-LEN(IMBUF$),0)
50105 IMMES%(1)=VARPTR(IMBUF$)+1 'Address of offset
50106 IMMES%(1)=CVI(CHR$(PEEK(IMMES%(1)))+
 CHR$(PEEK(IMMES%(1)+1)))
50110 IMMES%(2)=CVI(CHR$(IMCOL%) +
 CHR$(IMROW%)) 'Screen coordinates
50115 IMMES%(3)=CVI(CHR$(IMFTYP%) +
 CHR$(IMSTYP%)) 'Sign control and format
50120 IMMES%(4)=CVI(CHR$(IMFILL%) +
 CHR$(IMATTR%)) 'Attribute and fill
50125 IF IMFTYP% <> 2 THEN IMW1%=0
50130 IMMES%(5)=CVI(CHR$(IMW2%) + CHR$(IMW1%)) 'Field width
50135 DEF USRO=VARPTR(IMCAL%(0))
50140 IMMES%(0)=USRO(VARPTR(IMMES%(0)))
50150 RETURN
```

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strings, as I have here. This is due primarily to GWBASIC's being an interpreter rather than a compiler. As a program executes and arrays are created and strings grow and shrink, the interpreter moves variables around in memory. So the results of a VARPTR function may not be valid after the execution of a DIM statement or any string function. All you can do is remain aware of this phenomenon and use the results of a VARPTR function as soon after its execution as possible.

Turbo Basic

The Turbo Basic command set includes members specialized for direct access of the CPU. Consequently, you don't have to perform all the black magic as in GWBASIC. See listing 4.

You'll notice that deriving the contents of the first two entries in the message array has become considerably more complex. Gosh, there are actual PEEK statements in there. In Turbo Basic, it's much more difficult to determine the physical location of a string variable.

Listing 4: *Calling IMAN from Turbo Basic.*

```
DEFINT A-Z
%UNSIGNED = 0     'No sign
%SIGNED = 1       'Signed, show plus
%ISALPHA = 0      'Alphanumeric field
%ISINTEGER = 1    'Integer field
%ISFLOAT = 2      'Floating-point field
%IMANVEC = &H62   'Interrupt vector for IMAN

DIM IMMES%(6)            'Message
IMBUF$=STRING$(80,0)     'String buffer

DEF FNCALLIMAN%(IMROW%,IMCOL%,IMSIGN%,IMTYPE%,IMFILL%,IMATTR%,IMW1%,IMW2%)
    DEF SEG 'Set segment to start-up
    IF LEN(IMBUF$)<80 THEN
        IMBUF$=IMBUF$+STRING$(80-LEN(IMBUF$),0)
    END IF
    IMMES%(0)=CVI(CHR$(PEEK(0))+CHR$(PEEK(1)))
    IMMES%(1)=VARPTR(IMBUF$)+2
    IMMES%(1)=CVI(CHR$(PEEK(IMMES%(1)))+CHR$(PEEK(IMMES%(1)+1)))
    IMMES%(2)=CVI(CHR$(IMCOL%)+CHR$(IMROW%))
    IMMES%(3)=CVI(CHR$(IMTYPE%)+CHR$(IMSIGN%))
    IMMES%(4)=CVI(CHR$(IMFILL%)+CHR$(IMATTR%))
    IF IMTYPE% <> %ISFLOAT THEN IMW1%=0
    IMMES%(5)=CVI(CHR$(IMW2%)+CHR$(IMW1%))

    REG 8,VARSEG(IMMES%(0)) 'Set DS register
    REG 2,VARPTR(IMMES%(0)) 'Set BX register
    CALL INTERRUPT &H62
    FNCALLIMAN%=INSTR(IMBUF$,CHR$(0))
END DEF
```

Listing 5: *Calling IMAN from QuickBASIC.*

```
DECLARE FUNCTION IMAN% (IMROW%, IMCOL%, IMSTYP%,
 IMFTYP%, IMATTR%, IMFILL%, IMW1%, IMW2%)

DIM SHARED INPUTREGS AS RegTypeX, OUTPUTREGS AS RegTypeX
DIM SHARED IMMES%(6)
DIM SHARED IMBUF$

FUNCTION IMAN% (IMROW%, IMCOL%, IMSTYP%, IMFTYP%,
 IMATTR%, IMFILL%, IMW1%, IMW2%)

IF LEN(IMBUF$) = 0
 THEN IMBUF$ = STRING$(80, 0)
 ELSE IMBUF$ = IMBUF$ + STRING$(80 - LEN(IMBUF$), 0)
IMMES%(0) = VARSEG(IMBUF$)    'Segment
IMMES%(1) = VARPTR(IMBUF$)+2  'Address of offset
IMMES%(1) = CVI(CHR$(PEEK(IMMES%(1))) +
 CHR$(PEEK(IMMES%(1)+1)))
IMMES%(2) = CVI(CHR$(IMCOL%) + CHR$(IMROW%))
IMMES%(3) = CVI(CHR$(IMFTYP%) + CHR$(IMSTYP%))
IMMES%(4) = CVI(CHR$(IMFILL%) + CHR$(IMATTR%))
IF IMFTYP% <> 2
 THEN IMW1% = 0
IMMES%(5) = CVI(CHR$(IMW2%) + CHR$(IMW1%))

INPUTREGS.bx = VARPTR(IMMES%(0))
INPUTREGS.ds = VARSEG(IMMES%(0))
CALL INTERRUPTX(&H62, INPUTREGS, OUTPUTREGS)
IMAN% = INSTR(IMBUF$, CHR$(0))

END FUNCTION
```

Most variables are kept in a segment pointed to by the DS register, and it's a trifle to determine this segment using the VARSEG() operator (identical in function to the OFS() functions of C and Pascal). But when you sic VARPTR() and VARSEG() on a string variable, you end up with the address of a 4-byte string descriptor. This descriptor resides in the DS segment, and its last 2 bytes are the offset to the string body. The string body is kept off in another segment called the string segment, and you can find out where that is by looking in the first memory word of the data segment. Whew!

It's convenient to use Turbo Basic's constants to attach a symbolic name to the values that pick the format type and sign handling. This makes code easier to read and understand, because you can write statements such as

IMFTYP% = %ISFLOAT

rather than

IMFTYP% = 2

For all their differences, there are still many similarities between the code in listing 4 and the code that I presented for GWBASIC. Two new statements appear in the vicinity of the actual call to IMAN. The CALL INTERRUPT statement is Turbo Basic's way of calling a software interrupt directly. This statement takes one argument, the interrupt vector number.

But before you call a software interrupt, you need some way of loading the processor's registers. Enter the REG statement. REG takes two arguments. The first argument must resolve to a value in the range 0 to 9 and select which register you want loaded. Your chosen register is loaded with the value given by the second argument. As you execute REG statements, you are actually writing information into a "register buffer" that Turbo Basic maintains internally. When the CALL INTERRUPT statement executes, Turbo Basic first loads the processor's registers from the register buffer before transferring to the interrupt routine.

Once again, I've built the function so that it returns the number of characters that the user actually entered.

Microsoft QuickBASIC

The interface to the input manager for Microsoft's QuickBASIC, which appears in listing 5, looks like an amalgam of all the listings that have preceded it.

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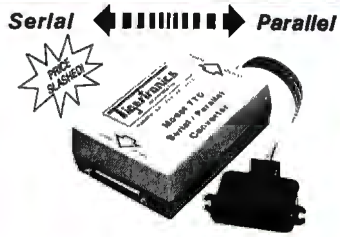

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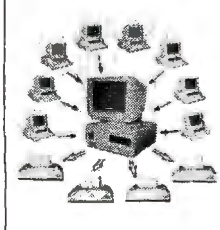

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2MEGKIT*	IBM PS/2	100ns 1MEG x 9 SIMM (2 each)	469.95
41256A9A-10	262,144x9	100ns 256K x 9 SIP (Has Leads)	49.95
41256A9B-80	262,144x9	80ns 256K x 9 SIMM	64.95
421000A8B-10	1,048,576x8	100ns 1MEG x 8 SIMM	164.95
421000A9A-80	1,048,576x9	80ns 1MEG x 9 SIP (Has Leads)	169.95
421000A9B-80	1,048,576x9	80ns 1MEG x 9 SIMM	169.95

*Upgrade for Models 30, 50Z and 60

7400

Part No.	1-9	10+	Part No.	1-9	10+
7400	.29	.19	7474	.39	.29
7402	.29	.19	7475	.49	.39
7404	.29	.19	7476	.45	.35
7405	.35	.25	7483	.59	.49
7406	.39	.29	7485	.65	.55
7407	.39	.29	7486	.45	.35
7408	.35	.25	7489	2.25	2.15
7410	.29	.19	7490	.49	.39
7411	.35	.25	7493	.45	.35
7414	.49	.39	7495	.59	.49
7416	.35	.25	74107	.29	.19
7417	.35	.25	74121	.39	.29
7420	.29	.19	74123	.49	.39
7427	.29	.19	74125	.49	.39
7430	.29	.19	74147	1.99	1.89
7432	.39	.29	74150	1.35	1.25
7438	.39	.29	74151	.39	.29
7442	.49	.39	74154	1.35	1.25
7445	.75	.65	74161	.69	.59
7446	.89	.79	74174	.59	.49
7447	.89	.79	74175	.59	.49
7473	.39	.29	74193	.79	.69

74LS

74LS00	.26	.16	74LS139	.49	.39
74LS02	.28	.18	74LS151	.49	.39
74LS03	.28	.18	74LS153	.49	.39
74LS04	.28	.18	74LS154	1.29	1.19
74LS05	.28	.18	74LS157	.45	.35
74LS06	.59	.49	74LS161	.49	.39
74LS07	.59	.49	74LS163	.49	.39
74LS08	.28	.18	74LS164	.59	.49
74LS09	.28	.18	74LS165	.75	.65
74LS10	.26	.16	74LS166	.89	.79
74LS11	.29	.19	74LS173	.45	.35
74LS14	.49	.39	74LS174	.39	.29
74LS20	.28	.18	74LS175	.39	.29
74LS21	.29	.19	74LS191	.59	.49
74LS27	.35	.25	74LS192	.69	.59
74LS30	.28	.18	74LS193	.69	.59
74LS32	.28	.18	74LS194	.69	.59
74LS38	.35	.25	74LS221	.69	.59
74LS42	.49	.39	74LS240	.59	.49
74LS47	.85	.75	74LS241	.59	.49
74LS73	.39	.29	74LS244	.59	.49
74LS74	.35	.25	74LS245	.79	.69
74LS75	.39	.29	74LS257	.49	.39
74LS76	.39	.29	74LS259	.99	.89
74LS83	.55	.45	74LS273	.89	.79
74LS85	.55	.45	74LS279	.49	.39
74LS86	.29	.19	74LS367	.49	.39
74LS90	.49	.39	74LS373	.79	.69
74LS93	.49	.39	74LS374	.79	.69
74LS123	.49	.39	74LS393	.89	.79
74LS125	.49	.39	74LS541	1.29	1.19
74LS132	.49	.39	74LS590	5.95	5.85
74LS138	.49	.39	74LS688	2.39	2.29

74S/PROMS*

74S00	.25	74S188*	1.49
74S04	.25	74S189	1.49
74S32	.25	74S240	1.39
74S74	.25	74S244	.99
74S112	.25	74S287*	1.49
74S124	1.25	74S288*	1.49
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74S174	.29	74S472*	2.95
74S175	.39	74S571*	2.49

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CD4002	.19	CD4052	.59
CD4007	.19	CD4053	.59
CD4011	.19	CD4060	.65
CD4012	.25	CD4066	.29
CD4013	.29	CD4069	.25
CD4015	.29	CD4070	.29
CD4016	.29	CD4071	.19
CD4017	.49	CD4072	.19
CD4018	.49	CD4073	.19
CD4020	.59	CD4081	.19
CD4021	.49	CD4093	.35
CD4024	.45	CD4094	.89
CD4027	.35	CD4503	.39
CD4028	.49	CD4511	.59
CD4029	.69	CD4518	.75
CD4030	.35	CD4520	.69
CD4040	.65	CD4522	.75
CD4042	.49	CD4528	.69
CD4043	.59	CD4538	.79
CD4046	.65	CD4543	.79
CD4047	.65	CD4584	.49
CD4049	.29	CD4585	.69
CD4050	.29		

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8085A-2	3.59
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8087-1 (10MHz)	169.95
8087-2 (8MHz)	129.95
8088 (5MHz)	4.95
8088-2 (8MHz)	6.95
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81C55	4.25
8205	9.95
82C11	6.95
8212	1.99
8216	1.39
8224	1.49
8228	1.49
8237-5	4.25
8243	1.95
8250A	4.95
8250B (For IBM)	5.95
8251A	1.95
8253	1.89
8253-5	1.95
82C53-5	3.95
8254	4.95
8255A-5	2.95
82C55A-5	4.49
8256	11.95
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80387-20 (20MHz)	399.95
80387-25 (25MHz)	499.95
82284 (8MHz)	5.49
82288 (8MHz)	6.95

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ADC0808CCN	5.49
ADC0809CCN	3.75
ADC1205CCJ-1	19.95
DAC0808LCN	1.49
AY-3-1015D	4.95
AY-5-1013A	2.95

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Part No.	Function		Price
2016-12	2048x8	120ns	2.95
2102	1024x1	350ns	.89
2112	256x4	450ns MOS	2.49
2114N	1024x4	450ns	.99
2114N-2L	1024x4	200ns Low Power	1.49
21C14	1024x4	200ns (CMOS)	.49
5101	256x4	450ns (CMOS)	1.95
6116P-1	2048x8	100ns (16K) CMOS	3.19
6116P-3	2048x8	150ns (16K) CMOS	2.79
6116LP-1	2048x8	100ns (16K) LP CMOS	3.59
6116LP-3	2048x8	150ns (16K) LP CMOS	3.09
6264P-10	8192x8	100ns (64K) CMOS	6.75
6264P-15	8192x8	150ns (64K) CMOS	6.29
6264LP-10	8192x8	100ns (64K) LP CMOS	6.95
6264LP-12	8192x8	120ns (64K) LP CMOS	6.75
6264LP-15	8192x8	150ns (64K) LP CMOS	6.49
6514	1024x4	350ns CMOS	3.25
43256-10L	32,768x8	100ns (256K) Low Power	10.95
43256-15L	32,768x8	150ns (256K) Low Power	9.95
62256LP-10	32,768x8	100ns (256K) LP CMOS	11.95
62256LP-12	32,768x8	120ns (256K) LP CMOS	11.25
62256LP-15	32,768x8	150ns (256K) LP CMOS	10.95

DYNAMIC RAMS

TMS4416-12	16,384x4	120ns	5.95
TMS4416-15	16,384x4	150ns	5.49
4116-15	16,384x1	150ns (MM5290N-2)	1.09
4128-15	131,072x1	150ns (Piggyback)	4.49
4164-100	65,536x1	100ns	2.75
4164-120	65,536x1	120ns	2.39
4164-150	65,536x1	150ns	2.15
41256-60	262,144x1	60ns	6.95
41256-80	262,144x1	80ns	5.75
41256-100	262,144x1	100ns	3.95
41256-120	262,144x1	120ns	3.69
41256-150	262,144x1	150ns	3.25
41264-12	64Kx4	120ns Video RAM	10.95
41464-80	65,536x4	80ns	5.95
41464-12	65,536x4	120ns	4.49
41464-15	65,536x4	150ns	4.25
51258-10	262,144x1	100ns Static Column	8.95
511000P-80	1,048,576x1	80ns (1 Meg)	13.95
511000P-10	1,048,576x1	100ns (1 Meg)	12.95
514256P-10	262,144x4	100ns (1 Meg)	14.49
514258-10	262,144x4	100ns Static Column	26.95

EPROMS

TMS2516	2048x8	450ns (25V)	4.95
TMS2532	4096x8	450ns (25V)	5.95
TMS2532A	4096x8	450ns (12.5V)	5.25
TMS2564	8192x8	450ns (25V)	6.95
TMS2716	2048x8	450ns (-5V, +5V, +12V)	6.49
1702A	256x8	2K (1µs)	4.25
2708	1024x8	450ns	6.95
2716	2048x8	450ns (25V)	3.49
2716-1	2048x8	350ns (25V)	3.95
27C16	2048x8	450ns (25V) CMOS	4.25
2732	4096x8	450ns (25V)	3.95
2732A-20	4096x8	200ns (21V)	3.95
27C32	4096x8	450ns (25V) CMOS	4.25
2764-25	8192x8	250ns (21V)	3.95
2764A-20	8192x8	200ns (12.5V)	4.19
2764A-25	8192x8	250ns (12.5V)	3.49
27C64-15	8192x8	150ns (12.5V) CMOS	4.95
27128-20	16,384x8	200ns (21V)	5.95
27128-25	16,384x8	250ns (21V)	5.25
27128A-15	16,384x8	150ns (12.5V)	6.95
27128A-20	16,384x8	200ns (12.5V)	4.75
27C128-25	16,384x8	250ns (21V) CMOS	5.95
27256-15	32,768x8	150ns (12.5V)	8.49
27256-20	32,768x8	200ns (12.5V)	5.49
27258-25	32,768x8	250ns (12.5V)	4.95
27C256-15	32,768x8	150ns (12.5V) CMOS	7.25
27C256-25	32,768x8	250ns (12.5V) CMOS	5.49
27512-25	65,536x8	250ns (12.5V)	7.25
27C512-15	65,536x8	150ns (12.5V) CMOS	9.95
27C512-25	65,536x8	250ns (12.5V) CMOS	7.49
27C010-15	131,072x8	150ns (12.5V) CMOS (1 Meg)	19.95
68764	8192x8	64K 450ns (25V) (Chip Enable)	14.95
68766-35	8192x8	64K 350ns (25V) (Output Enable)	15.95

EEPROMS

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2817A	2048x8 350ns 5V **Read/Write**	6.95
2864A	8192x8 250ns 5V **Read/Write** (Pin 1, No R/B)	10.95
2865A	8192x8 250ns 5V **Read/Write**	10.95

6500/6800 68000 Series

Part No.	Price
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6502	2.19
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6510	14.95
6526	13.95
6526A	14.95
6545-1	3.95
6560	6.95
6567	24.95
6572	6.95
6581 (12V)	12.95
6582 (9V)	7.95
8502	7.95
8564	2.95
8566	8.95
8701	9.95
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901227-03	15.95
901229-05	15.95
901460-03	1.95
901486-06	2.95

*No specs available
**Note: 82S100PLA = U17 (C-64)

74C/CMOS

74C00	.25	74C174	.39
74C02	.25	74C175	.39
74C04	.25	74C192	.99
74C08	.25	74C194	.49
74C10	.19	74C221	1.79
74C14	.49	74C240	.99
74C32	.45	74C244	1.49
74C74	.49	74C373	1.49
74C85	1.29	74C374	1.49
74C86	.29	74C911	5.95
74C89	2.95	74C912	7.95
74C90	.99	74C915	1.19
74C151	1.75	74C917	3.95
74C154	2.95	74C920	3.95
74C157	1.49	74C921	3.95
74C160	.49	74C922	3.95
74C161	.49	74C923	3.95
74C162	.49	74C925	4.95
74C173	.49	74C926	5.95

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TM1	1µf @ 35V	.19	TM6.8	6.8µf @ 35V	.59
TM2.2	2.2µf @ 35V	.25	TM10	10µf @ 35V	.69

POTENTIOMETERS

Values available (insert ohms into space marked "XX"): 500Ω, 1K, 2K, 5K, 10K, 20K, 50K, 100K, 200K, 1MEG

43PXX 3/4 Watt,15Turn **.99** | **63PXX** 1/2 Watt, 1Turn **.89**

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PN2222	.13	PN2907	.13	1N4004	.10
2N2222A	.29	2N4401	.15	1N4148	.07
2N3055	.69	1N270	.25	1N4735	.25
2N3904	.12	1N751	.15	C106B1	.49

SWITCHES

JMT123 SPDT, On-On	1.25	206-8 SPST, 16-pin DIP 1.19
MPC121 SPDT, On-Off-On	1.25	MS102 SPST, Momentary .39

D-SUB CONNECTORS

DB25P Male, 25-pin .69 | DB25S Female, 25-pin .75

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XC556R T1¾, Red	.13	XC556Y T1¾, Yellow .17
XC556G T1¾, Green	.17	

IC SOCKETS

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8LP	.11	8WW	.49
14LP	.12	14WW	.65
16LP	.13	16WW	.69
24LP	.21	24WW	1.19
28LP	.23	28WW	1.39
40LP	.29	40WW	1.89

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Part No.	Price	Part No.	Price
74HC00	.19	74HC175	.59
74HC02	.19	74HC221	.89
74HC04	.19	74HC240	.69
74HC08	.19	74HC244	.79
74HC10	.19	74HC245	.79
74HC14	.29	74HC253	.49
74HC30	.25	74HC259	.49
74HC32	.25	74HC273	.49
74HC74	.29	74HC373	.69
74HC75	.35	74HC374	.69
74HC76	.35	74HC595	1.29
74HC85	.55	74HC688	1.49
74HC86	.29	74HC943	6.95
74HC123	.59	74HC4040	.79
74HC125	.49	74HC4049	.29
74HC132	.49	74HC4050	.29
74HC138	.45	74HC4060	.69
74HC139	.39	74HC4511	.99
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LM308N	.65	.59	ULN2004A	.79	.69
LM309K	1.49	1.25	26LS29	2.95	2.75
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LM317T	.69	.59	26LS33	1.75	1.49
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LF351N	.49	.39	LM3914N	1.95	1.75
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LM358N	.59	.49	7812K	1.29	1.19
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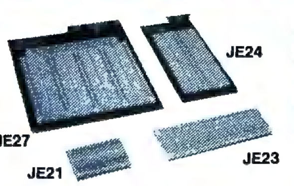

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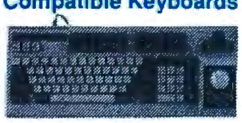

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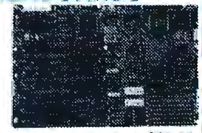

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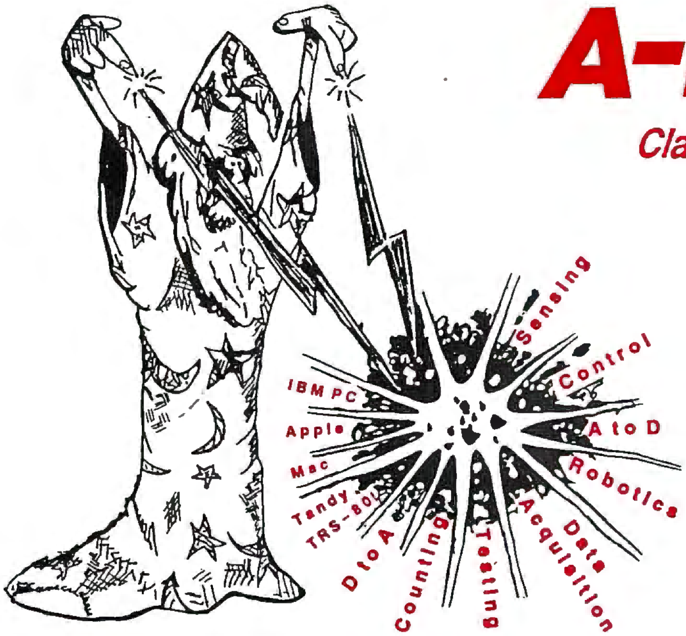

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Important

All A-BUS Systems: ♦ Come assembled and tested ♦ Include detailed manuals with schematics and programming examples ♦ Can be used with almost any language (BASIC, Pascal, C, assembler, etc.) using simple "IN" and "OUT" commands (PEEK and POKE on some computers) ♦ Can grow to 25 cards (in any combination) per adapter ♦ Provide jumper selectable addressing on each card ♦ Require a single low cost unregulated 12V power supply ♦ Are usually shipped from stock. (Overnight service is available.)

About Alpha Products

Founded in 1976 for the purpose of developing low cost I/O devices for personal computers, Alpha has grown to serve over 70000 customers in over 60 countries. A-BUS users include many of the Fortune 500 (IBM, Hewlett-Packard, Tandy, Bell Labs, GM...) as well as most major universities. A-BUS products are U.S. designed, U.S. built, and serviced worldwide.
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Relay Card: 8 individually controlled industrial relays each with status LED's (3A at 120VAC contacts, SPST). **RE-140: $142**

Reed Relay Card: 8 reed relays (20mA at 60VDC, SPST). Individually controlled and latched, with status LEDs. **RE-156: $109**

D/A converter: 4 Channel 8 Bit D/A converter with output amplifiers and separate adjustable references. **DA-147: $149**

24 line TTL I/O: Connect 24 input or output signals (TTL 0/5V levels or switches). Variety of modes. (Uses 8255A) **DG-148: $72**

Digital Input: 8 optically isolated inputs. Input can be 5 to 100V voltage levels or switch closures. **IN-141: $65**

Digital Output Driver: 8 outputs: 250mA at 12V. Drive relays, solenoids, stepper motors, lamps, etc. **ST-143: $78**

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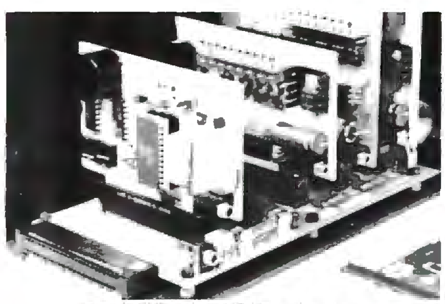
Options: ► 5 amp/phase power booster for 1 motor: **PD-123: $49**
► Remote "teach" keypad for direct motor control: **RC-121: $54**



A large A-BUS system with two Motherboards
Adapter in the foreground plugs into PC,XT,AT type slot.

Stepper Driver Kit: For experimenting with stepper motors. Includes 2 MO-103 motors and a ST-143 dual driver **PA-181: $99**

Stepper Motors: (4 phase, unipolar)
MO-103: 2¼" dia. ¼" shaft. 7.5°/step. 12V. 5 oz-in torque. **$15**
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A-BUS Adapters

► Can address 64 ports and control up to 25 A-BUS cards.
► Require one cable. Motherboard required for more than 2 cards.

A-BUS Parallel Adapters for:

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TRS-80 Model 3,4,4D Y-Cable available if 50 pin bus is used. **AR-132: $54**
TRS-80 Model I Plugs into 40 pin expansion bus. **AR-131: $39**
Tandy Color Computers Fits ROM slot. Multipak or Y-Cable **AR-138: $49**

A-BUS Cable: Necessary to connect any parallel adapter to one A-BUS card or to first motherboard. 50 pin, 3 ft. **CA-163: $24**
Special Cable for two A-BUS cards **CA-162: $34**

Serial Adapter: Connect A-BUS systems to any RS-232 port. Allows up to 500 ft from computer to A-BUS. **SA-129: $149**

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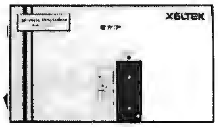

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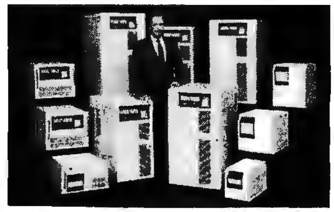

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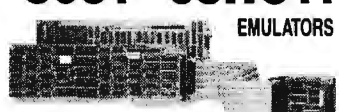

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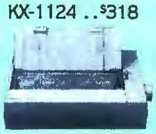

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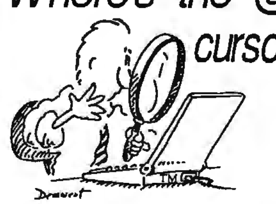

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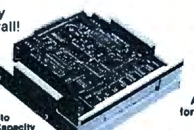

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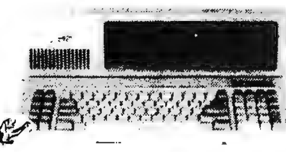

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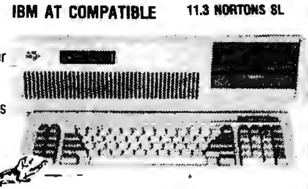

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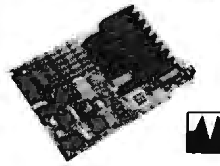

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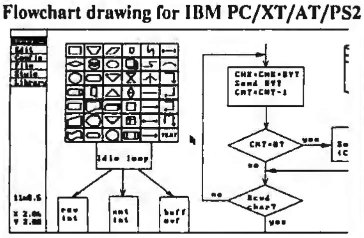

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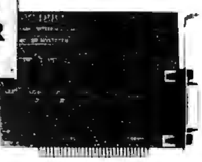

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- **DFI**
  - HS 3000 + 185
- **Logi Tech**
  - Scanman Plus 165

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- AQUILA 8 Port Active Hub $212
- AQUILA Arcnet Card 89
- Novel Netware Call
- SMC 131 Arcnet 145
- Tiara Passive Hub 38
- Other Boards Call

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  - Power Flex 286/40MG $1329
  - Other Models Call
- **AST**
  - Bravo 5 829
  - Other Models Call
- **Everex** Call
- **Mitsubishi**
  - Laptop 2350
- **NEC**
  - Multispeed HD 2209
- **Panasonic**
  - FX 1650 645
- **Samsung** Call
- **Toshiba**
  - T-1000 673
  - T-1200F 1409
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  - T-1600 3350
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  - T-5200 5745
- **Zenith**
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- **Murata**
  - 1200 649
- **NEC**
  - Multifax 1245
- **Sharp**
  - FO 300 731
  - UX 80 1015
- **Toshiba**
  - 30100 905
  - 3300 849
  - 3600 1055

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- **AST**
  - Rampage Plus 286 $360
  - Six Pack Plus w/384K 220
  - All Other Models Call
- **ATI**
  - EGA Wonder 165
  - VGA Wonder 256K 259
  - VGA Wonder 512K 319
- **Hercules**
  - Graphics Card Plus 174
  - Incolor 206
  - All Other Models Call
- **Intel**
  - 80287-8 185
  - 80287-10 216
  - 80387-16 319
  - 80387-20 365
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  - 8087-1 155
  - 8087-2 115
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  - V-Ram (256K) 359
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  - 449 239

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- **Wyse**
  - 30 $289
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  - Evercom 12 INT 55
  - Evercom 24 + w/MNP 140
- **Hayes**
  - 1200B 145
  - 2400 339
  - Other Models Call
- **Practical**
  - 2400 EXT 168
  - 2400 INT 119
- **Prometheus**
  - 1200B w/Software 49
  - 2400B w/Software 100
  - Other Models Call
- **US Robotics**
  - Courier 2400 259
  - Courier 2400E w/MNP 315
  - HST 9600 595

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- **Amdek Monitors**
  - 210A $100
  - 410 139
- **Mitsubishi**
  - Diamond Scan 495
  - Diamond Scan 16" 1149
- **NEC**
  - Monograph System 1293
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OPTICAL WORM

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Write Once Read Many... California Digital has just purchased from **PRIAM CORPORATION**, 300 hundreds of Information Storage's ISI/525WC optical WORM drive. The WORM's were manufactured for Priam and bare the Priam logo. Chosen "Editors Choice" by PC Magazine, (March 29, 1988) the 525 provides 230 megabytes of random accessible data on each doubled sided flippy cartridge. (manually flipped).

Optical storage is the perfect medium for maintaining "on line" programs or other static data. Ideal for catalogs, part lists or any application where random accessibility is required.

The ISI/525 is available in IBM internal configuration but an external enclosure may be added. Supplied with one cartridge, ESDI/PC controller, cable and transparent optical software. For additional information, contact Steven in our technical support department (213) 217-1947. The ISI/525 is a current production drive.

Dest Scanner

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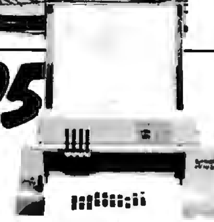
$3995

Image scanning for OCR text, photographs, and line art. High resolution 300 DPI, the DEST PC Scan Plus/651 is capable of rendering photographs to 32 halftone shades. Also inputs text directly from printed pages to ASCII files or directly into most word processing programs. Electronic status display. Available for both the **Macintosh** (SCSI) or the IBM/PC. Please specify 115 or 230 volt.

Original price was over $3000, now is your chance to purchase a DEST scanner for only $559.

NEC/890 Laser $3095

PC Magazine has chosen the NEC-890 best laser printer of the year. (Jan. 12, 1988). And its obvious why... the printer is Postscript, Hewlett Packard, and Apple compatible, and comes standard with three megabytes of memory. The 890 accepts data from parallel, serial and Apple-Talk devices.



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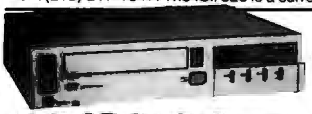
Automatic Paper Feeder

FAST,.. 22 inches per second. Size "B" four pen with auto pen capping and 128K/byte buffer. **HPGL** compatible, 19 built-in character fonts and automatic sheet feeder make the Hitachi 673 a super buy at only $795. RS/232 and centronics parallel.



$539

CD/ROM Complete Kit

Doctor, lawyer, Indian chief... Virtually every industry and profession is disseminating information on CD/ROM. One compact disk, the same size as an audio disk, can store over 500 magabytes of data in High Sierra format.

Below is a listing of some of the CD/ROM drives currently available from California Digital. The best value is the Eclipse 430 external drive. The 430 includes PC/XT interface, cables, sampler software and MS/DOS extension. It also offers an audio output feature for mulitmedia presentations. The system is Manufactured in Japan by one of the Worlds largest producers of magnetic storage equipment. A super value at only $539.

Eclipse 430 external system	$539
Hitachi 1503S External system	695
Hitachi 3500 Internal system	595
Hitachi internal drive only	519
NEC CDR/77 External drive only	.695
NEC CDR/80 Internal drive only	..639
NEC interface kit for above	159
Sony CD/510 internal drive only	..559
Sony 6101 external drive only	795
Sony 230B interface kit	159
Panasonic LF5000 "write once"	1895
Panasonic interface kit for above	.359

$1299

Saba Scanner $359

The Saba Scanner inputs a printed page of evenly spaced text in less than three seconds. Included OCR software allows your computer to transfer printed pages into ASCII files or directly to spreadsheets and most word processing programs.

Archival data, legal briefs... No problem. Simply inset the page into the Saba and in seconds the document is digested into your computer and ready for editing. Also does line drawings that do not require gray tones. Limited quantities available. Original price $1299; now only $359.

SCANNERS

SABA SCANNERS		
page scanner with OCR software	1299	359
hand held scanner with OCR soft.	799	159
DEST SCANNERS		
PC/651 scan+ 32 shades	3995	559
2000 edge feed scanner	935	719
MICROTECH300G 256 gray scales	2195	1759
DFI HandiScan 300 with Halo	359	199
PRINCETON GRAPHICS LS-300	1095	789
PANASONIC		
RS505 Image page scanner	1499	999
RS506 Page scanner	1899	1259

PRINTERS

HEWLETT PACKARD		
Laser Printer II, 300x300	2595	1659
Laser Printer II/D double sided	3995	2995
QMS PS/810 2 Meg., 35 fonts, Post/S.	5495	3879
APPLE Laser Writter NT	4550	3659
NEC890 Postscript, 3 meg	4975	3095

DIGITIZERS

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HDG 1212 Puma 12x12"	595	359
HDG 1515 15x15	969	659
Tiger 1111C, 12x12 stylus extra	727	487
HDG 3648, 36x48"	5357	3995
SUMMAGRAPHICS		
Summa 1201 plus 12x12"	599	379
TB 3648, 36x48"	4748	3729
KYE Genius Tablet w/4 but. mouse	599	279
CALCOMP		
25180, 12x18"	1275	999
91480, 36x48"	4118	3389

MicroSoft Mouse

Your choice, MicroSoft "Inport Buss Mouse" or "Serial Mouse". The industry standard, list price $150, now available for only $59. Includes software and manual. Packaged in OEM boxes.

$59

PLOTTERS

HOUSTON INSTRUMENTS		
DMP 41 single pen, 3 ips, C&D	2995	2295
DMP 52 single pen, 16 ips, C&D	3295	2495
DMP 56C size A-E, 16 ips	5695	3095
DMP61 single pen, 32 ips, A-D	4295	3095
PC695A 4 pen, size "B" 3 ips	799	595
CALCOMP PLOTTERS		
1023 Artisan A-D, 8 pen, 30 ips	4895	3795
1043GT size A-E, 8 pen, 24 ips	7995	5495
HEWLETT PACKARD		
7475A 6 pen size "B"	1895	1495
7550A 8 pen size "B" 32 ips	3900	2995
7595A 8 pen, size A-E, 24 ips	9990	7595
HITACHI PLOTTERS		
673/BM 4 pen, size "B" auto feed	2455	795
675 size "A-D" 8 pen	5600	2995
FUJITSU Imagegraph, 6 pen, 11x32	1295	895
IOLINE PLOTTERS		
LP3700 size E, 10 ips	4195	3195
LP3700MP 8 pen size "E" 10 ips	4695	3495
ROLAND PLOTTERS		
DPX2000 size "C" 8 pen with stand	2995	2195
DPX3300size"D" 8 pen with stand	4995	3495
ENTER COMPUTER		
SP600 size "B" 6 pen	995	659
SP1000 single pen size A-D	3995	2795
JDL 850, size "C" one meg. memory	3845	2789
VERSATEC 8524 Electrostatic	16,900	13789
NUMONICS		
5460 size "A-D"	2495	1859
5860 size "A-D" 8 pen	7495	5759

CAD SOFTWARE

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AutoCad version 10,	2995	2195
AutoSketch Std & Enhanced 2.0	99	79
VERSACAD Designer	2995	1995
GENERIC CAD level 1	49	35
AMERICAN SM. BUS'N. Design Cad	299	179

Build Your Own Computer

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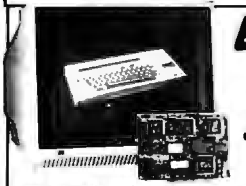
AT Case Only

California Digital has all the components needed to customize your own computer. Buy as much computing power as you need now, and up grade when the need arises. Here are some examples of components available:

8 slot 10 MHz Mother board	$89
8 slot 12 MHz baby AT Motherboard	229
Full size five drive AT case	35
Four drive XT case	25
101/102 AT/XT German mfg. Keyboard	57
200 watt AT power supply	59
TEC 360K/Byte disk drive	49
Monochrome card, printer port	19
MonoGraphics (hercules) printer port	45
Color Graphics card	49
EGA Color Multi Resolution II	139
I/O card, serial & parallel	35
I/O PLUS, Ser/Par'l. clock, game	59
Disk I/O, disk control, clock, game	59



EGA Color Monitor

$219

Ideal for CAD/CAM and Desk Top publishing applications. The Roland CD/240 color monitor has a resolution of 720 pixels by 400/480 lines on a .31mm dot pitch 12" non-glare screen VGA specifications in text mode EGA in graphic mode.

California Digital has made a special purchase and is able to offer the CD/240 EGA/VGA RGB color monitor for only $219.

Full featured, 132 column, multi-resolution video color adapter card available for only $139 additional. Comparable card package would retail for $1095.

40 Megabyte Hard Disk Kit

$359

Forty megabyte internal hard disk drive, controller and cables all for only $359.

The kit includes the a 40 millisecond Miniscribe 3650 drive and a half slot Western Digital controller.

40 Meg. Tape Back-up

$179

$659

Head Crash, Power Spikes or just poor disk maintenance...

Don't loose data because you didn't back up. The Alloy/40 is an inexpensive way to save and restore files in the event that your data has been distroyed. This 40 megabyte half height tape back is manufactured by North Americas largest producer of data retrieval equipment.

No need to purchase a separate tape controller... the Alloy/40 attaches directly to your existing floppy disk controller. Supplied software allows your computer to back up any time Day or Night. Come back in the morning and 40 megabytes of irreplacable data has been stored on one Scotch DC/2000 data cassette.

Back up entire hard disk, modified files only, or by file name. Loss of data is inevitable but when you are backed up on an Alloy/40 its not a catastrophe. Model 250 for PC/XT $179; Model 500 for AT $239.

DISK DRIVES

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5" DISK DRIVES

TEC501 ½ height sgl.side	29
TEC504 ½ ht. double sided	49
TANDON 101/4 full ht. 96 TPI	69
TEAC FD55BR half height	89
TEAC FD55FR 96 TPI, half ht.	119
TEAC FD55GFR for IBM AT	109
PANASONIC 455 Half Height	89
PANASONIC 475 1.2 Meg./AT	99
Fujitsu 5¼" double sided	69
Dual enclosure for 5¼" drives	69

3½" DISK DRIVES

SONY MP-73W, 1.44 Meg	139
TEAC 235HF 1.44 Meg	99
5¼" Form Factor Kit	20

8" DISK DRIVES

QUME 842 double sided	189
QUME 841 single sided	99
SHUGART 851R dbl.sided	319
SHUGART 801R sgl.sided	259
SIEMENS 100/8 sgl. sided	119
REMEX RFD4000 dbl. sided	189

Five Inch Winchester Disk Drives

Price does not include controller.	each	two+
SEAGATE 225 20 Meg. ½ Ht.	239	229
SEAGATE 238 30 Meg. RLL	259	249
SEAGATE 251/1 51 M. 28mS.	459	445
SEAGATE 4096 96 M. 35mS.	559	539
MINISCRIBE 8425 25 M 65ms	239	227
MINISCRIBE 3650 50M 61 ms.	319	309
MINISCRIBE 6085 90 meg.	459	435
MINISCRIBE 3053 25 ms. ½ ht.	359	339
FUJITSU 2242 55 M. 35mS.	1299	1229
FUJITSU 2243 86 M. 35mS.	1695	1619
RODIME RO-204E 53 Meg.	895	859
MAXTOR XT1140 140 Meg.	1495	1450
MAXTOR XT2190 192 Meg.	1919	1875
TOSHIBA MK56 70 M. 30mS.	1289	1229
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DTC 6280 AT/ESDI 1:1 interleave	229
DTC 5150 XT/MFM hard drive	69
DTC 7280 AT/MFM 1:1 interleave	189
ADAPTEC 2072 RLL controller	89
ADAPTEC 2372A 1:1 interleave	159
WESTERN DIGITAL WD/1002GEN	89
WESTERN DIG. 1006VMM2 1:1 & fpy.	139
WESTERN DIGITAL 1007VMM2 ESDI	239

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ADAPTEC 5¼" foot print	259
WESTERN DIGITAL 1002-05E 5¼"	229
OMTI 20L	89

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4164-150	65536x1	150ns	16	2.49
4164-120	65536x1	120ns	16	2.89
4164-100	65536x1	100ns	16	3.39
TMS4464-12	65536x4	120ns	16	4.29
41256-150	262144x1	150ns	16	2.59
41256-120	262144x1	120ns	16	2.95
41256-100	262144x1	100ns	16	3.15
41256-80	262144x1	80ns	16	3.75
41256-60	262144x1	60ns	16	5.25
414256-100	262144x4	100ns	20	12.95
414256-80	262144x4	80ns	20	13.45
1 MB-120	1048576x1	120ns	18	11.95
1 MB-100	1048576x1	100ns	18	12.35
1 MB-80	1048576x1	80ns	18	12.95

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NEW LOW PRICES!

PART#	SIZE	SPEED	FOR	PRICE
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41256A9B-80	256K x 9	80ns	SIMM/PC	49.95
421000A8B-10	1MB x 8	100ns	SIMM/MAC	109.95
421000A9B-10	1MB x 9	100ns	SIMM/PC	113.95
421000A9B-80	1MB x 9	80ns	SIMM/PC	119.95
256K9SIP-80	256K X 9	80ns	SIP/PC	54.95
256K9SIP-60	256K X 9	60ns	SIP/PC	64.95
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If you've been thinking about replacing your XT motherboard with an AT, this is the optimum time! Prices on AT type motherboards are about as low as they'll ever get. Your initial investment need be no more than the cost of the motherboard.

If you have at least 512K of memory (using 41256 chips), then all your current peripherals (with the possible exception of serial ports and keyboard*) will be usable on a replacement motherboard. This includes your case, power supply, display, floppy drives and hard disk drives. To use your current memory, you may have to run at a slower clock setting, but even then you'll get 4-5 times your current throughput.

Board replacement is easy. Begin by unplugging the power connector and all peripheral cables. Open the case and remove the cards from their slots. Then remove the screws holding the motherboard and slide the board out. Reverse this procedure to install the new board.**

Later, to enhance performance, you can replace some of the peripherals with their faster AT counterparts, like a 1:1 interleave AT F/H controller, more and/or faster memory, and a 16-bit display card.

Derick Moore, Director of Engineering

* Original PC keyboards need replacement/some serial ports may be too slow
**Some cases may require minor modifications to accommodate the additional 1 inch of board length and new mounting holes.

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2732A	4096x8	250ns	21V	24	3.95
2764	8192x8	450ns	12.5V	28	3.49
2764-250	8192x8	250ns	12.5V	28	3.69
2764-200	8192x8	200ns	12.5V	28	4.25
27C64	8192x8	250ns	12.5V	28	4.95
27128	16384x8	250ns	12.5V	28	4.25
27128A-200	16384x8	200ns	12.5V	28	5.95
27256	32768x8	250ns	12.5V	28	4.95
27256-200	32768x8	200ns	12.5V	28	5.95
27C256	32768x8	250ns	12.5V	28	5.95
27512	65536x8	250ns	12.5V	28	8.95
27C512	65536x8	250ns	12.5V	28	9.95
27C101-20	131072x8	200ns	12.5V	32	29.95

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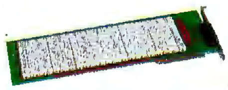

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7404	.19	74LS74	.24	74LS322	3.95
74LS04	.16	74S74	.49	74LS367	.39
74S04	.29	74LS138	.39	74LS373	.79
7406	.29	74LS155	.59	74LS374	.79
7408	.24	74LS163	.39	74LS393	.79
74LS08	.18	74LS240	.69	74LS682	3.20
7432	.29	74LS244	.69	74LS688	2.40

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- SHIRT POCKET SIZE!
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DATARASE II

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Model	Timer	# of Chips	Intensity (uW/Cm²)	Unit Cost
PE-140	NO	9	8,000	$ 89.95
PE-140T	YES	9	8,000	$139.95
PE-240T	YES	12	9,600	$189.95
PL-265T	YES	30	9,600	$255.95

IC SOCKETS/DIP CONNECTORS

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8 PIN ST	.11	8 PIN WW	.59	ZIF-14	5.95
14 PIN ST	.11	14 PIN WW	.69	ZIF-16	5.95
16 PIN ST	.12	16 PIN WW	.69	ZIF-20	6.95
18 PIN ST	.15	18 PIN WW	.99	ZIF-24	7.95
20 PIN ST	.18	20 PIN WW	1.09	ZIF-28	7.95
24 PIN ST	.20	24 PIN WW	1.49	ZIF-40	10.95
28 PIN ST	.22	28 PIN WW	1.69		
40 PIN ST	.30	40 PIN WW	1.99		

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DB15P	.59	DB15S	.69
HDB15P	1.49	HDB15S	1.59
DB19P	.69	DB19S	.75
DB25P	.69	DB25S	.75
DB37P	1.35	DB37S	1.39
DB50P	1.85	DB50S	2.29

IDC'S

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IDE34	.89
IDS20	.65
IDS34	.75
IDB09P	1.39
IDB09S	1.45
IDB25P	2.25
IDB25S	2.35

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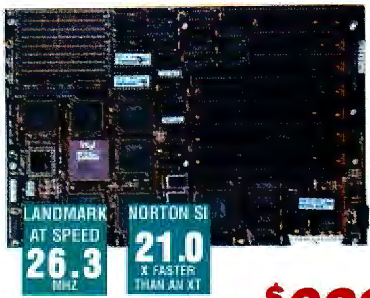
MODULAR CIRCUIT TECHNOLOGY



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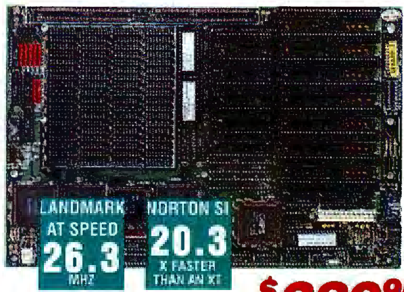

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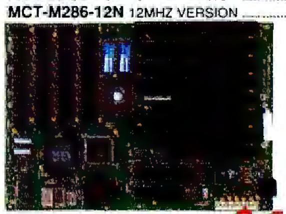

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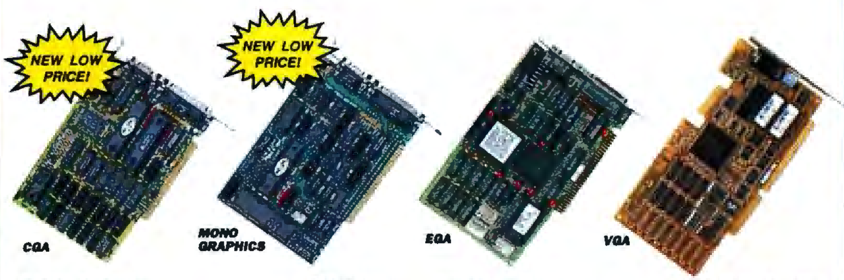

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32.7MB RLL	ST-238	65 MS	5-1/4"	$219	$279	$379
42.8MB	ST-251-1	28 MS	5-1/4"	$339	$389	$449
65.5MB RLL	ST-277-1	28 MS	5-1/4"	$389	$449	$549
80.2MB	ST-4096	28 MS	5-1/4"	$569	—	$679
122.7MBRLL	ST-4144R	28 MS	5-1/4"	$699	$759	$859
21.4MB	ST-125	40 MS	3-1/2"	$259	$299	$373
32.1MB RLL	ST-138	40 MS	3-1/2"	$289	$339	$429

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48.6MB	ST-157N	40 MS	3-1/2"	$389
21.3MB	ST-225N	65 MS	5-1/4"	$329
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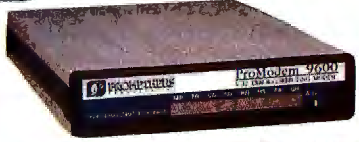

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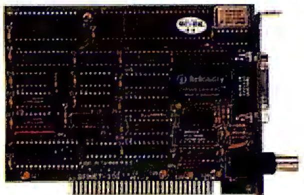

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EDITORIAL INDEX BY COMPANY

Index of companies covered in articles, columns, or news stories in this issue
Each reference is to the first page of the article or section in which the company name appears

COMING UP IN BYTE

PRODUCTS IN PERSPECTIVE:

Short Takes for January include Fremont Communications' Fax Board, Fox Software's FoxPro, Hewlett-Packard's intelligent graphics controller, Artisoft's LANtastic, and a "portable mainframe" from Opus systems.

New product coverage continues with our **What's New** section. As you can see from this issue, What's New has been revamped to provide expanded communications coverage in a special, continuing section—Connectivity. Regional What's New coverage will also be undergoing some changes in the months ahead, with more input from local users groups in each of our major geographic areas. Watch for the news reflecting activities near you.

People who spend a lot of time working with their computers necessarily depend on them to work at peak performance all the time. One of the major frustrations of all computer users, then, is a malfunction in the disk drive. What's causing the problem? How do I fix it? Indeed, can it be fixed at all? Our **Product Focus** on disk utilities brings a ray of hope to the afflicted by examining an array of the most widely used self-help products on the market.

Reviews: After BYTE's landmark first coverage of the NeXT computer, we promised a full-scale review when we'd had time to really take the machine apart and delve into its capabilities. The time has come to deliver on that promise, and a system review will deliver the full story of this unique machine.

We'll also be looking at a selection of low-end introductions in computing's fastest-growing segment, the laptop market. Hardware reviews will include a piece on high-capacity hard disk drives for the Macintosh, low-cost PostScript printers, and Macintosh Ethernet adapters. Language reviews include PC Macsyma and GoldWorks II from Gold Hill Computers; in the applications section, we'll look at PageGarden. The short reviews in our Reviewer's Notebook lineup for January include the Fortron 386/33, Dr. Pascal, and TimeScribe.

IN DEPTH:

The In Depth section focuses on **the state of chips**, with pieces covering the current level of development in integrated circuitry. Our authors and editors will let you in on what the latest developments are, what they will mean to you in the coming months and years, and even how to go about creating your own IC designs in case there's nothing on the market that will do what you have in mind.

FEATURES:

January is the time for the big **BYTE awards** feature. It's the issue in which we have a chance to look back at the hardware and software of the previous year and deliver our hindsight verdicts on those products we think are the most significant. And 1989 was a good year for that. Given that there are always strong opinions on what introductions had the most merit, we're having a fine time putting this one together, and we think that will be reflected in our choices.

On top of that, we're working on features detailing the **state of Macintosh AI and expert-systems software**, a look at a **new C programming language for parallel processors**, and a survey of **the BBS nation**—what is it that we're doing on-line, all the time, everywhere?

Our columnists continue in fine form, with tips, observations, and opinions in our **Expert Advice** section, while the **Hands On** columns provide more lengthy coverage of specific areas of interest.

And here in the back of the book, **Print Queue** and **Stop Bit** give us back-to-front readers the chance to show everybody else that the way we look at a magazine has been right all the time.

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881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900
901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920
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961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980
981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000
1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020
1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040
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1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100
1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120
1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140
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1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180
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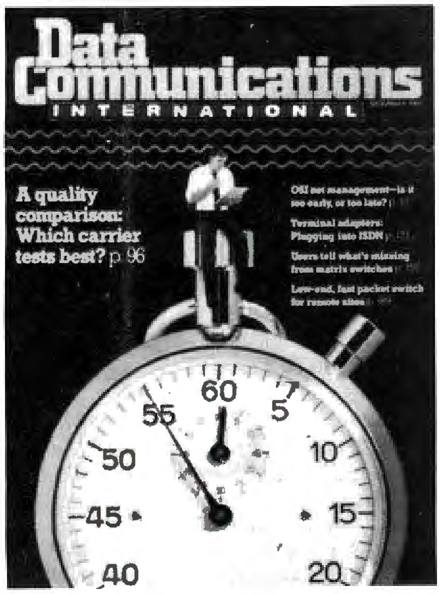

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continued from page 392

Building the contents of the message array proceeds in much the same way as the GWBASIC version. (Is this any surprise? Both languages come from Microsoft.) The only difference is in the use of the VARSEG function that I've already introduced in the Turbo Basic interface and whose operation is similar. I say "similar" because here VARSEG returns the proper segment of the string. Note that, as in Turbo Basic, VARPTR() returns the offset of the 4-byte string descriptor, so you've got to execute a couple of PEEK() functions to get the address of the string body.

The heart of the function lies in the CALL INTERRUPTX() function, a specialized version of QuickBASIC's CALL INTERRUPT. It allows you to set the contents of the DS and ES registers prior to the CALL (a procedure that CALL INTERRUPT does not permit).

The CALL INTERRUPTX() function requires three parameters: the interrupt vector to be called, a record structure (called a Type in QuickBASIC) defining the contents of the CPU registers going into the function, and a record structure to hold the contents of the registers coming out of the function. You define records using the trusty DIM statement (see the listing), and in this case the record type is internally defined as RegType. (When you execute QuickBASIC, be sure to include the /L switch at the command line. This loads the library that holds the definition for the CALL INTERRUPTX routine.)

A trashed screen can undermine the user's faith in an application.

TopSpeed Modula-2

Just when you think you've got the whole court covered, someone puts a spin on the ball that you didn't expect. Take TopSpeed Modula-2's treatment of strings, for example. Its strings do not use a length byte, as Pascal's do. Instead, strings are defined as character arrays and use a termination character—but not a null as in C; they use a formfeed character (decimal 12).

Listing 6 is the source code for the Modula-2 interface to IMAN. Once again, you've first got to get the string into a form IMAN will accept—which amounts to replacing the formfeed with a null. And when IMAN returns, you put the string back into a form Modula-2 will accept—which amounts to replacing the null with a formfeed.

TopSpeed Modula-2 uses `Intr()` to call an interrupt, and, as with most other languages, the creators have defined a record type that lets you set the CPU's registers. For the most part, the Modula-2 routine looks like a cross between the Pascal version and the C version.

Listing 6: *The IMAN interface for TopSpeed Modula-2.*

```
(* IMAN interface for TopSpeed Modula-2 *)
FROM Str IMPORT Length,Insert,Pos;
FROM SYSTEM IMPORT Seg,Ofs;
FROM IO IMPORT WrInt,WrLn;
FROM Lib IMPORT Intr;
IMPORT IO,Str,SYSTEM,Lib;

VAR
 imbuf: ARRAY [0..79] OF CHAR;

(*
** This procedure calls IMAN and returns the number of
** characters in the field. It expects a global character
** array imbuf.
*)
PROCEDURE
CALLIMAN(imrow,imcol,imsign,imtype,
    imfill,imattr,imw1,imw2: INTEGER) : INTEGER;

VAR
    pcregs : SYSTEM.Registers;
    immes: ARRAY [0..5] OF INTEGER;

BEGIN

Insert(imbuf,CHR(0),Length(imbuf));
    immes[0]:=Seg(imbuf);  (* Segment *)
    immes[1]:=Ofs(imbuf);  (* Offset *)
    immes[2]:=(imrow << 8) + imcol;
    immes[3]:=(imsign << 8) + imtype;
    immes[4]:=(imattr << 8) + imfill;
    IF imtype<>2 THEN imw1:=0
    END;
    immes[5]:=(imw1 << 8) + imw2;

    (* Set up registers *)
    pcregs.BX:=Ofs(immes[0]);
    pcregs.DS:=Seg(immes[0]);
    (* Call the interrupt *)
    Intr(pcregs,62H);

    IF Pos(CHR(0),imbuf)=0 THEN
       RETURN 0
    ELSE
       Insert(imbuf,CHR(12),Pos(CHR(0),imbuf));
       RETURN Length(imbuf)
    END;
END CALLIMAN;
```

End of Field

It's nice to see that at least some degree of compatibility isn't all that difficult to achieve, even across languages. Of course, I owe a lot to the fact that everything this month is running on the IBM PC family of machines. It would be a chore—and probably a pointless one—to convert IMAN to the 68000 and do the same thing with Macintosh packages.

Although IMAN is small compared to other projects I've presented here and embodies almost nothing theoretical, it's one of those seemingly trivial tools that can make a great deal of difference in any final application. Your entry screens will look clean, and you won't have to "?Redo from start" ever again. ■

Editor's note: *The source code for IMAN is available as IMAN.ASM on disk and on BIX, along with the examples used in this article. See page 5 for details.*

Rick Grehan is the director of the BYTE Lab. He has a B.S. in physics and applied mathematics and an M.S. in computer science/mathematics from Memphis State University. He can be reached on BIX as "rick_g."

Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

PRINT QUEUE

Hugh Kenner

Sixty-One Diamonds for the Mind

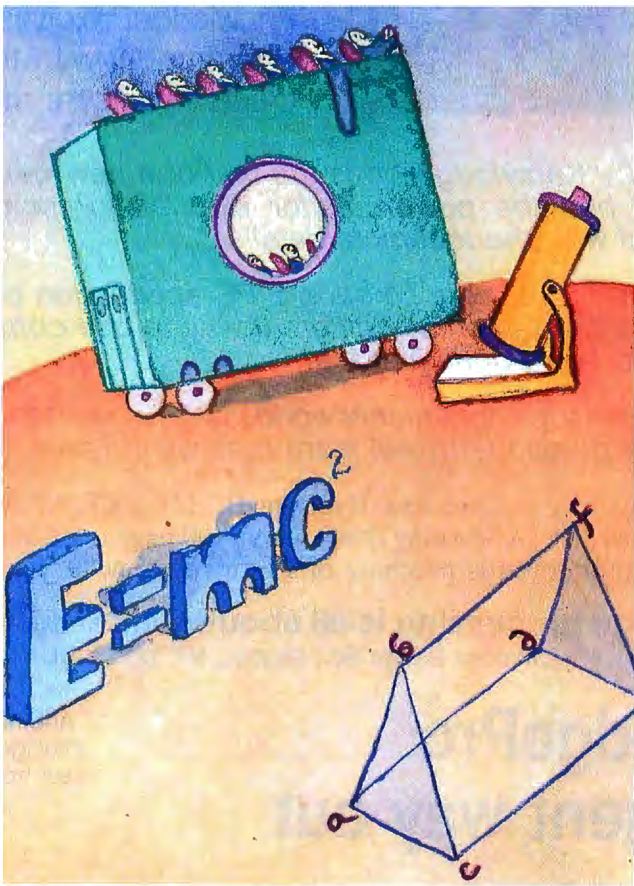
THE TURING OMNIBUS:
61 Excursions in Computer Science

by A. K. Dewdney

Martin Gardner's monthly "Mathematical Games," which dated from before some present-day readers of BYTE had begun to learn to count, was for years and years *Scientific American*'s single most popular feature. Gardner prided himself on *not* being a mathematician. One of his strengths was a transparent expository manner.

Another strength was the trust he'd earned from a network of professionals, for some of whom being reported on by Gardner could often be preferable to journal publication. John Horton Conway's game of Life—"automaton" structures that mutated, spawned, and vanished to the baton of just two rules, even as they modeled vast themes of self-replication—that game, later a mainstay of recreational computing (not to mention MIT hacking), was first described in a 1970 Gardner article.

One of his sources, the late Rufus Isaacs, once told me about Gardner's idiosyncratic files, which included a folder for each "interesting" number. An example would be 407, the largest number expressible as the sum of the cubes of its digits. (Apart from 1, by the way, the smallest such number is 153, and just two others exist. Also by the way, such files as Gardner's are potentially infinite, thanks to the proof that no uninteresting number exists. For more about that, stick around.)



I also learned from Isaacs how, as late as the mid-1970s, as the priesthood of numeracy was getting thoroughly hooked on silicon, a principled Gardner was still keeping hardware at bay. Like the fly-fishing gentleman who routinely releases the fish once he's taken his pleasure in the exercise of elegant skill, he recoiled from such mechanized number crunching as simply gets you a number, and he tended to identify machinery with that. He never did yield, not even to the trifling extent of buying—let alone mastering—a pocket calculator.

But such purism couldn't last; computation was shouldering in. Since his retirement, Gardner has had three successors: computer metaphorist Doug Hofstadter, computer connoisseur Brian Hayes, and, currently, computer virtuoso A. K. ("Kee") Dewdney. Kee's Toronto-based brother Christopher is a poet with scientific interests, whose *The Immaculate Perception* (University of Toronto Press, 1986) is worth hunting out: the only prose-poem book I can imagine that has need for a drawing of the cerebral cortex. Their forebear Selwyn was a minor novelist. Kee teaches computer science at the University of Western Ontario, in a town called, grandly, London. Altogether an interesting family, resistant to specialization in a way perhaps nowadays peculiar to Canada. (Let me not conceal my own Canadian origins.)

Back in August 1988, BYTE ran my review of Dewdney's *The Armchair Universe*, a collection of *Scientific American* pieces. *The Turing Omnibus* is something quite different. Although loyal readers will recognize embedded excerpts from columns, its material is mostly new. And it displays computer science at ease in a Gardneresque terrain where rigor consorts with play.

Dewdney-watchers will spot a familiar method. His initial moves generally exploit the no-man's-land between computer science and what universities fund as "mathematics." The latter, said Bertrand Russell, is a domain where you never know (a) what you're talking "about," nor (b) whether what you're saying is true. G. H. Hardy at Cambridge was famous for his joy in professing a subject that had no applications whatsoever. Computerdom, though, does have its tests of truth (a crude one: stake your money on the printout). Also, it's constantly flirting with "about."

Thus a spreadsheet: That's "about" accounting? Yes; the very name is rooted in accounting. Yet join the top edge to the bottom, the left edge to

continued

the right, and though you've done something of little use to an accountant, you've coped with a demon that besets programmers of Conway's Life, where the cellular automaton may try to shift itself clear off the edge of the paper. The way you've coped is by eliminating all edges. For the Life game demands, ideally, an infinite sheet, and by defining edges as joined, you could simulate certain properties of that boundless page—its unboundedness if not its infinite extent—with a spreadsheet like Multiplan. I've not seen it done, though Brian Hayes did suggest the idea in 1983.

Most of the book's excursions contain no formal algorithm whatever.

And once you've centered your attention on that Multiplan Life game, lo, "spreadsheet" has receded to the status of metaphor. You next realize that in buying Multiplan software, you acquired a way to think about manipulating symbols in space, never mind what its designers thought it was "for."

You see how such a line of thought can work us toward a domain exempt from the obsession with special-case "results" that distressed Gardner. Such is the domain through which the book is driving. There, principles are at play in cascading generality, though "applications" are never unthinkable.

A neat example is tour 20, headed Generative Grammars. It begins by stating that "the growth of certain types of plants can be modeled, to an extent, by a formal scheme known as a *Lindenmeyer system.*" But "such systems are really a special kind of generative grammar," since "words in a formal system are produced by a stepwise process of replacement," symbols being "replaced by certain words given in a list of 'productions' " until growth has ceased, at which point a new "word" has been generated by the grammar. Compiler writers understand that already. The rest of us may wonder whether we're reading about plants or languages. The answer is, both.

Do not be deterred. Most of the 61 tours in *The Turing Omnibus*'s repertory are as simple in principle as the two rules of Life. Thus, starting with the general concept of algorithms (tour 1), Dewdney gives us a recipe for enchiladas complete with a REPEAT...UNTIL loop (that's when you sauté chopped onion and clove *until* golden). Then within a page we've a "wallpaper" algorithm, nine lines long including a FOR loop, that uses the enchilada method to place intricate patterns on your screen. That in turn is followed by a skeletal Pascal translation, just to illustrate how, the way you can implement enchiladas at the stove, you can implement wallpaper at the terminal. At the end, we find two problems and a short bibliography. It all takes seven pages exactly.

Granted, the recipe/algorithm analogy has been used before. What's peculiar to Dewdney here is his crisp economy, his compactness of notation, and his way of handing the details over to you. No more than Gardner is he a hardware buff, nor even, in any way Borland or Microsoft would want us to understand, a software buff. He's happy weaving patterns of pure concept, stating them compactly, and letting us take it from there. If we choose to remain with just a firm understanding, aglow like a diamond in the mind, nothing suits him better. Or if we undertake a workable program in our language of choice, he'll want us to enjoy the process and the results.

Most of *The Turing Omnibus* excursions contain no formal algorithm whatever, though often, as when game trees (minimax method) get lucidly expounded in five pages, an algorithm does lurk just offstage. (Minimax, after all, underlay a 1962 program by Arthur Samuel that once beat a U.S. state checkers champion.)

Or here's tour 11, error-correcting codes, something we were hearing about at the time of the Neptune flyby a few months back. As those pixel-by-pixel images traversed millions of miles, they faded toward the level of background noise. A pixel embraced 32 possible levels of gray; since 32 is 2^5, the Jet Propulsion Laboratory used 5 bits per pixel? No, 32 bits per pixel; then redundancy could catch up to seven errors.

Dewdney's wonderfully lucid diagram shows how this works: all meaningful combinations of 32 white and black squares, from which it's evident that any two differ in exactly 16 places. (My "meaningful" swamps much detail spelled out by Dewdney.)

If only 1 bit is wrong, the transmitted pixel will differ from a row in the diagram by only 1 bit "and cannot be mistaken for any other word." The same is true for up to seven errors. We're quite safe in simply selecting the closest match. But if *eight* errors have occurred, the received word may differ from some other row in the diagram just as much as it differs from the intended row. Then we have two choices, equally plausible. What's more, we are not stumbling forward blindfolded; we know about a local undecidability. (That's a reason to transmit the picture more than once, random errors being unlikely to recur exactly.)

Or here is the fast Fourier transform (tour 29), devised in 1965 by Colley and Tukey and now compressed to an 11-line algorithm. It's drawn on in tour 26 (CAT scanning), which deals with the problem of nonredundantly recovering a three-dimensional image.

Or, here's the formidable predicate calculus (tour 54), "one of the most powerful languages known for the expression of mathematical ideas and thought." Dewdney's exposition has recourse to the old problem of ferrying wolf, goat, and cabbage across a river in a rowboat that will hold just two at a time; but wolf left alone with goat means an eaten goat, goat with cabbage an eaten cabbage. (Here, by the way, I'll register my one complaint. Though fluent with +, −, *, and /, I'd welcome a table specifying signs I'm less used to, such as an inverted A and a reversed E.)

Oh—the proof that there's no uninteresting number? Well, 2 is the first even, 3 the first prime (and all primes are interesting), 4 the first square.... Keep moving along till you come to a number about which you can't think of anything to say. So here's the first uninteresting number! That makes it interesting. Now check tour 21 (recursion, via the Sierpinski curve) and apply such a principle recursively. QED. ■

Computer Science Press, New York: 1989, 415 pages, $24.95

Hugh Kenner is a professor of English at Johns Hopkins University. His reviews have appeared in publications like the New York Times *and* Harper's. *His recent books include* A Sinking Island *and* Mazes. *He can be contacted on BIX as "hkenner."*

Your questions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

HEARD IT THROUGH THE HELP LINE

You don't have to be crazy to do customer support, but it helps

"No, the manuals aren't lost," said the client on the other end of the line. "It's just that we can't find them anywhere."

I waited for her to laugh at her own joke before I politely joined in. But she just kept talking. Then it dawned on me that she was completely serious.

Ever since I took a job providing nationwide personal computer support through a telephone help line, I have found myself in a state of bewildered amazement over the things I hear being said and the situations I find myself involved in day after day.

Once a client called in and complained that ever since a power surge was installed in the computer, nothing was working right.

Another time, a client called in to get someone to tell her how to "floormat" a disk.

Then there was the woman who got upset after I repeatedly tried to get her to tell me the exact kind of personal computer she was having trouble with. "I told you I don't know what kind of machine it is," she told me heatedly. "All I know is that it's an IBM that was made into a Compaq."

I remember the time an excited client called in to demand that someone come out and fix his computer *now*. When he had powered the machine on, he had gotten the message "Bad or Missing Command Interpreter" instead of the main menu of his accounting package, as expected. When I took the call, I thought that such a simple problem should take no more than 3 minutes to solve. Little did I know.

"Do you have a DOS disk available?" I asked.

"DOS disk?" he asked.

I explained to the client—after repeated efforts—what a DOS disk was, and I convinced him that he probably had one lying around somewhere. Then I waited while he thrashed through piles of disks and stacks of user manuals (most, if not all, probably still wrapped in factory-fresh plastic). I listened to the sound of objects being tossed to and fro and hitting the floor. Eventually, the client found the elusive and mysterious DOS disk.

I said, "Sir, could you please put that disk into drive A and then reboot the machine?"

"I've got to have this machine running today," he raged. "I'm losing thousands of dollars' worth of business because this !$?/*@*#! machine won't work. I want somebody out here right now to fix this !%@?!@*#! machine. I can't afford to wait another hour. It has to be running today, do you understand me?"

"Yes, sir, we'll get you up and running in a minute. Would you *please* put the DOS disk in drive A and reboot the machine?" I responded, ignoring his outburst.

"Reboot?" he asked, puzzled.

I explained the process to him, and he was finally able to get the system booted. I wanted to make sure the hard disk drive was accessible and that his files were still there. The simplest way to do that was to execute a DIR C: directory command. Since this client (and many, many others who call in) obviously had not had a whole lot of personal computer training, I reasoned that I had better give him some practice and have him do DIR all by itself first, saving the exotic things like "C:" for later.

"Sir, we need to see what files are on that disk. Would you please type DIR and then press the Enter key?"

"*What?*"

"Please just type the letters *D, I, R* and then press the Enter key," I repeated patiently.

"Type *P, R,* and do WHAT?"

"Please just type the letters *D, I, R* and then press the Enter key," I responded in a controlled voice.

"Type *D, I, R, E, N, T, E, R?*" the client asked.

"No, sir. Please type *D, I, R* and then press the Enter *key*," I said, my voice rising.

"Type *D, I, R* and press Enter?" the client asked.

"Yes, yes, press the *D* key, then the *I* key, then the *R* key, and then press the Enter key—four keystrokes in all," I begged.

"OK, OK," he bellowed.

Through the phone line I clearly heard the sound of keys being pressed, as the client followed the instructions. First I heard four very slow clicking sounds. Then I heard a faster volley of six clicks, then five slower clicks, then a burst of profanity. Then a loud, pounding, keyboard-destroying, machine-gun crescendo of clicking sounds too fast to count blasted across the line. Then all I heard was silence.

"What's that you said to type?" the client demanded belligerently.

Situations and conversations like these are an everyday occurrence on the help line. It's a tough job, but somebody has to do it.

As soon as I find that somebody, I'll gladly let him or her have my place. ■

Stop Bit is an open forum for informed opinion on topics related to personal computing. The opinions expressed are those of the author and not necessarily those of BYTE or its staff. Your contributions and comments are welcome. Write to: Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458.

William Lee is employed by a large, nationwide personal computer dealer (at least, he was the last time we checked). He can be reached on BIX c/o "editors."

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